DOCUMENT RESUME

ED 200 410 SE 034 453

TITLE Pennsylvania's Energy Curriculum for the Secondary Grades: Earth Science.
INSTITUTION Pennsylvania State Dept. of Education, Harrisburg.
SPONS AGENCY Pennsylvania State Governor's Energy Council, Harrisburg.
PUB DATE 80
NOTE 66p.; For related documents, see SE 034 450-457. Maps may not reproduce well.

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS *Earth Science; *Energy; Environmental Education; Field Trips; *Geology; Natural Resources; *Science Education; Science Instruction; *Secondary School Science

ABSTRACT

Two dozen energy-related earth science lessons comprise this guide for secondary school teachers. Intended to provide information about energy issues that exist in Pennsylvania and throughout the world, the activities cover topics such as coal mining, radioactivity, and the distribution of oil and gas in Pennsylvania. Lessons include objectives, procedures, illustrated student handouts, and teacher references. Also listed are mines, museums, and power plants in Pennsylvania that earth science classes could visit. (WB)

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PENNSYLVANIA'S ENERGY CURRICULUM FOR THE SECONDARY GRADES

Earth Science

SE 034 453

Pennsylvania Department of Education 1980
Funds Provided by Governor's Energy Council

Commonwealth of Pennsylvania
Dick Thornburgh, *Governor*

Department of Education
Robert G. Scanlon, *Secretary*

Office of Basic Education
Ronald H. Lewis, *Commissioner*
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Health, Science and Technology Division
Irvin Edgar, *Chief*
John J. McDermott, *Senior Science Adviser*

Pennsylvania Department of Education
P.O. Box 911, 333 Market Street
Harrisburg, PA 17108

INTRODUCTION

This booklet is one of a series of secondary school discipline-centered guides intended to provide student activities which relate to that discipline and the topic of energy.

The Earth Science - Energy Curriculum Guide was developed to be used with the Pennsylvania Energy Primer published by the Governor's Energy Council. The activities in the guide rely heavily upon the graphs, charts, maps, and text of the Energy Primer.

The Earth Science disciplines of geology, astronomy, meteorology, and ocenaography have close and obvious relationships to almost all of the energy concerns which exist today. The student activities in the guide are intended to supplement existing Earth Science courses and provide students with information directly related to the energy issues that exist not only in Pennsylvania but throughout the world.

BIBLIOGRAPHY

Free publications of the Pennsylvania Geological Survey may be requested in classroom quantities; write to:

Pennsylvania Geological Survey
Department of Environmental Resources
P. O. Box 2357
Harrisburg, PA 17120

Map 10 Oil and Gas Fields Map of Pennsylvania, 1973, 9" x 12" (color).

Map 11 Distribution of Pennsylvania Coals, 1976, 9" x 12" (color).

Map 13 Physiographic Provinces of Pennsylvania, 1969, 8-1/2" x 11" (color).

ES 3 Ground Water in Pennsylvania, 1973, 42 p.

ES 6 Pennsylvania and the Ice Age, 1973, 33 p.

ES 7 Coal in Pennsylvania, 1976, 29 p.

ES 8 Geology of Pennsylvania's Oil and Gas, 1973, 28 p.

IC 82 The Mineral Industry of Pennsylvania in 1974, 1978, 39 p.

Cost of publications of the Pennsylvania Geological Survey may be obtained *only* from:

Department of General Services
State Book Store
P. O. Box 1365
Harrisburg, PA 17125

IC 65 Peat Bog Investigations in Northeastern Pennsylvania, 1969, 53 p., $0.85 plus state sales tax.

M 43 Uranium in Pennsylvania, 1961, 71 p., $1.30 plus state sales tax.

M 47 The Occurrence of Brine in Western Pennsylvania, 1962, 53 p., $0.90 plus state sales tax.

PR 190 Oil and Gas Developments in Pennsylvania in 1966, 1977, 56 p., $1.40 plus state sales tax.

U. S. Geological Survey's Popular Publications and Circulars are available free on request to:

Branch of Visual Services
U. S. Geological Survey
303 National Center
Reston, Virginia 22092

Popular Publications of the U.S. Geological Survey - A Catalogue, 23 pp.

Geysers, 23 pp.

Lithium, Nature's Lightest Metal, 15 pp.

Oil Shale - A Potential Source of Energy, 16 pp

Natural Steam for Power, 10 pp.

New Activities at the U.S. Geological Survey, 11 pp.

Nuclear Energy Resources - A Geologic Perspective, 15 pp.

Energy Resources of the U.S., U.S.G.S. Circular 650.

Organic-Rich Shale of the United States and World Land Areas, 1965, U.S.G.S. Circular 523.

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Water Demands for Expanding Energy Development, 1974, U.S.G.S. Circular 703.

The following materials are available from the source indicated.

Energy Perspectives 2, 1976, U.S. Department of the Interior.

Environmental Geology, by Edward A. Keller, 1976, Charles E. Merrill Publishing Co., Columbus, Ohio 43216.

Energy Alternatives: A Comparative Analysis, 1975, Government Printing Office, Washington, D.C. 20402, Stock No. 041-011-000254, 704 p., price $7.45.

Energy-Environment Source Book, National Science Teachers Association, 1742 Connecticut Avenue, NW, Washington, D.C. 20009, 1975, 279 pp. $4.00, No. 471-14692.

Energy-Environment Materials Guide, National Science Teachers Association, 1742 Connecticut Avenue, NW, Washington, D.C. 20009, 1975, 82 pp., $2.00, No. 471-14694.

Our Prodigal Sun, National Aeronautics and Space Administration, Washington, D.C. 20546, 14 pages, 35 cents, EP-118.

NASA and Energy, National Aeronautics and Space Administration, Washington, D.C. 20546.

Coal Facts, a folder of material on coal by the National Coal Association, Washington, D.C.

Energy Book #1, 1975, J. Prenis, Running Brook Press, Philadelphia, PA

Energy Book #2, 1976, J. Prenis, Running Brook Press, Philadelphia, PA

Energy From the Ocean, 1978, U.S. Government Printing Office, Washington, D.C.

Energy & Power, 1971, Scientific American, Freeman Co.

The PA Energy Abstract, 1978, The Governor's Energy Council.

The Environmental Impact of Electrical Power Generation: Nuclear and Fossil, 1975, U.S. Energy Research & Development Administration and the Pennsylvania Department of Education.

The Story of Natural Gas Energy, 1972, H. W. Springborn, Educational Services, American Gas Association, Arlington, VA.

PA Geology, 1978 April, "Exploratory Drilling in PA Indicates Substantial Reserves of Natural Gas", Shumack & Piotrowski.

SITES TO VISIT IN PENNSYLVANIA

Limerick Nuclear Generating Station
Linfield, PA

The information center is open Wednesday through Sunday and holidays from 10 a.m. to 4 p.m. It is closed on Christmas and New Year's Day.

The Limerick Nuclear Generating Station, which is being built by the Philadelphia Electric Company, will have two boiling water reactors. At the information center on the construction site, there are exhibits on atomic energy, electricity, and energy. A scale model of the Limerick Nuclear Generating Station and animated exhibits about its operation are also provided.

To arrange for group tours and special programs, or to obtain additional information, please contact:

Philadelphia Electric Company
Limerick Atomic Information Center
198 Longview Road
Linfield, PA 19468

Peach Bottom Atomic Power Station
Delta, PA

The information center is open Wednesday through Sunday and holidays from 10 a.m. to 4 p.m. It is closed on Christmas and New Year's Day.

Peach Bottom Atomic Power Station, with two boiling water reactors in operation, is one of the largest nuclear generating units in the world. In the information center are exhibits on electricity, nuclear power and energy. After a tour of the exhibit area, visitors may hear lectures and watch demonstrations and films in the auditorium.

Planned programs for groups can be scheduled. For additional information, please contact:

Philadelphia Electric Company
Atomic Information Center
Delta RD 1
Peach Bottom, PA 17563

Muddy Run Pumped-Storage Hydroelectric Plant
Drumore, PA

The Muddy Run Plant is operated in cooperation with the Conowingo Hydroelectric Station. Water is drawn from a reservoir above the powerhouse to generate electricity at times of peak demand, and water is pumped up into the reservoir at times of low demand. A 100-acre recreational lake was developed at the reservoir, with camping, fishing, boating, and picnicking facilities.

For additional information, please contact:

Philadelphia Electric Company
Community Relations Department
2301 Market Street
Philadelphia, PA 19101

Seldom Seen Valley Coal Mine
St. Boniface, PA

The mine is open daily from 9 a.m. to 8 p.m. from April 15 to Labor Day. It is open only on weekends from Labor Day to October 31.

Visitors may ride 2200 feet into the mine. Exhibits show many mining details. There is a museum at the main portal. Special group tours may be arranged.

For additional information, please contact:

Seldom Seen Valley Coal Mine
St. Boniface, PA 16675

Tour-Ed Mine
Tarentum, PA

The mine is open daily from 1 p.m. to 5:30 p.m. from Memorial Day to Labor Day. During May and September it is open only on Saturday and Sunday from 1 p.m. to 5:30 p.m.

The visitor views display areas a half-mile underground, showing various machines and mining methods of the past and present. The Tour-Ed Mine display was created from a worked-out section of an operating coal mine. For additional information, please contact:

Tour-Ed Mine
R. D. 2
Tarentum, PA 15084

Drake Well Park and Museum
Titusville, PA

The park and museum are open Tuesday through Saturday from 10:30 a.m. to 4:30 p.m.; or, Sundays from 1 p.m. to 4:30 p.m. They are closed on major holidays and election days.

The Drake well was the world's first commerical oil well. Today, an operating replica of the derrick and enginehouse, a museum, and a park with picnic area mark the site of this oil well. The museum contains working models, dioramas, an electric map, and complete audiovisual facilities, along with a research library on the beginnings of the oil industry.

For further information, please contact:

Drake Well Museum
R. D. 3
Titusville, PA 16354

Pioneer Tunnel Coal Mine
Ashland, PA

The mine is open daily from 10 a.m. to 7:30 p.m. from May 30 through Labor day weekend. During May, September, and October it is open on Saturdays and Sundays, 10 a.m. to 5:30 p.m. Group tours can be arranged during the off-season. The mine is operated through the cooperation of Ashland Borough and Reading Anthracite Company.

Pioneer Tunnel is a horizontal drift mine. The trip is 1200 feet into the side of Mahanoy Mountain. Visitors ride open cars pulled by a battery-operated mine motor. Miner guides tell and show the story of anthracite coal. For additional information write:

Ashland Community Enterprises
19th and Oak Streets
Ashland, PA 17921
717 875-3850

Three Mile Island Nuclear Station
Route 441
Middletown, PA

The observation center is open to the public. Check at the address below for hours.

Three Mile Island Nuclear Station was previously capable of producing more than 1,730,000 kilowatts of electricity, but both its reactors are shut down indefinitely since the accident in March of 1979. The observation center provides a multi-screen slide program, displays, and telescopes on the high observation deck.

For further information, contact:

Metropolitan Edison Company
P. O. Box 542
Reading, PA 19603
717 944-4041

Bruce Mansfield Plant
P. O. Box 128
Shippingport, PA 15077

Tours are encouraged; times are flexible to a mutual schedule. Reservations can be made by contacting Pennsylvania Power Company, 412 643-5000, ext. 245.

The Bruce Mansfield Plant is a coal-fired power plant with two lines operational and a third near completion. For further information contact:

Bruce Mansfield Plant
Tour Information Office
P. O. Box 128
Shippingport, PA 15077

Pennsylvania Anthracite Museum
Eckley
Pennsylvania

Tours are self-guided.

The coal miner's village of Eckley is the first unit in the creation of a Pennsylvania Anthracite Museum. Eckley is off Pa. 940 northeast of Hazleton, Luzerne County. For further information contact:

Pennsylvania Historical and
Museum Commission
P. O. Box 1026
Harrisburg, PA 17108

Susquehanna Nuclear Power Plant
U.S. Route 11
Berwick, PA

The information center along U.S. Route 11, five miles north of Berwick, is open to the public. This plant will have two boiling water reactors porducing electricity commercially by 1982. The information center contains exhibits on the geology of the site, atomic energy, electrical energy, and the reactors. To arrange for group tours and special programs contact:

Pennsylvania Power & Light Company
Two North Ninth Street
Allentown, PA 18101

MULTI-MEDIA MATERIALS

Landsat: Satellite for all Seasons

An environmental science series of six 15-minute, color programs for junior and senior high school students. Available from:

Agency for Instructional Television
Box A
Bloomington, Indiana 47401

Pennsylvania and Its Natural Resources

Color, 28-minute, film No. 272, available from:

Motion Pictures
Bureau of Mines
4800 Forbes Avenue
Pittsburgh, PA 15213

Activity: What is Coal?

Objective:

This exercise is presented to familiarize the student with coal: peat, lignite, bituminous, and anthracite; and ranks of coal.

What to do:

Observing the rank of coal:

1. Carefully examine the coal specimens and describe their physical appearance, such as: a) evidence of plant origin, b) evidence of increase in carbonization, c) hardness, d) luster, e) cleavage, f) other rock and mineral identifying characteristics.

2. Give evidence that indicates peat is the youngest member of the coal series.

3. What evidence indicates that anthracite is the highest ranked member?

4. Using crucible tongs, hold a small sample of peat in the Bunsen flame and note how long it takes it to ignite. When it catches fire, remove it from the flame and observe its burning. Do the same with the other three coals and record your observations: how each ignites, how smoky it burns, how rapidly it burns, what kind of odor is produced.

Complete the chart:

Coal	Speed of Ignition	Flame	Speed of Burning	Odor
peat				
lignite				
bituminous				
anthracite				

5. Does burning show that peat is the lowest ranked member?

6. Does the manner of burning of bituminous coal show that it still has volatile (gas) material in it?

Teachers Notes:

Coal being mined today in Pennsylvania was formed during late Paleozoic time, many millions of years ago, from ferns, mosses, and woody plant materials that accumulated in swamp environments. This coal is a rock composed of the altered and compressed remains of plant material. It occurs as layers within the surface rocks of the earth. Stored within the coal are the elements carbon, hydrogen, oxygen, and nitrogen as well as the sun's energy that the plants collected during their lifetime many millions of years ago. When coal is burned, these stored elements and the energy are released.

Materials needed: small samples of peat, lignite, bituminous coal, and anthracite; crucible tongs; Bunsen burner or alcohol lamp; matches.

Answers:

1. *Peat:* Plant material altered primarily by compaction, with easily recognizable plants and little to no carbonization; hardness - ½ (less than 1); luster - earthy and dull, nonmetallic; cleavage - none; organic plant matter, brownish in color, low in heat value, unconsolidated rock.

   Lignite: some recognizable plant structures with slight carbonization; hardness about 1 (less than 1 to 1.5); luster - dull to earthy; cleavage - slate-like, a fracture cleavage; brown to brown-black in color (brown coal); hardness, density, and specific gravity increase in the direction of carbonization, brittle, low in heat value, consolidated rock.

   Bituminous Coal: little to no recognizable plant structure with a high percentage of carbon; hardness 1 to 2; luster - dull, earthy, to glossy; cleavage - fracture cleavage, layered; burns readily with volatiles, black in color, medium in heat value, consolidated rock, brittle, specific gravity 1.0 to 1.8.

   Anthracite: no recognizable plant material or structure, high degree of carbonization; hardness 2.0 to 2.5; luster - glassy to submetallic; cleavage - conchoidal fracture; ignites not as easily as bituminous, much heat, burns with a short flame, little volatiles, high in ash, specific gravity 1.5 to 1.8, jet black in color; a non-crystalline amorphous rock, a chemical organic rock.

2. Looks like dried, compacted plant matter.

3. Hardness, density, and specific gravity and highest degree of carbonization.

4.

COAL	SPEED OF IGNITION	FLAME	SPEED OF BURNING	ODOR
Peat	fastest	orange-yellow, smoky	most rapid	burning of wood or leaves and twigs odor
Lignite		smoky, orange-yellow		charcoal or wood odor
Bituminous	to	smoky, blue-orange high flame	to	gaseous, methane or swamp gas and sulfur odor
Anthracite	slowest	white-blue low flame, little to no smoke	slowest	gaseous, little or no odor

5. Yes

6. Yes, gaseous odors

Activity: Carbon Dioxide Cycle and Coal

Objective:

To examine in depth the carbon dioxide cycle and the formation of coal.

What to do:

The Following statements explain the carbon dioxide cycle and its relationship to the formation of coal. Research the statements and explain to the class.

1. A large amount of CO^2 in the air increases plant growth because CO^2 is the source of the carbon in carbohydrates.

2. A very rapid accumulation of plant material is necessary before coal deposits are formed. This accumulation rate must exceed the rate of decay.

3. Bacteria aid in coal formation. The bacteria remove oxygen and hydrogen from carbohydrates, leaving carbon.

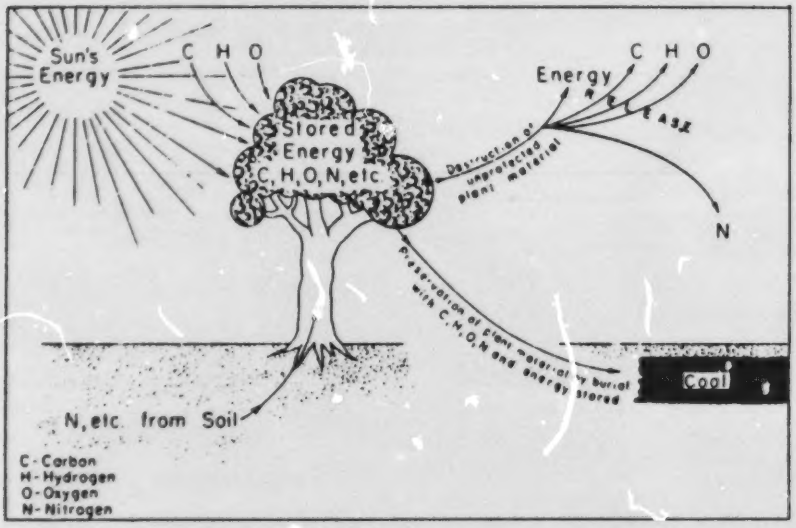
4. The amount of CO^2 in the atmosphere is less today than it was when coal was formed; most of the carbon in the CO^2 was changed to coal.

5. When coal is burned, it released CO^2 to the atmosphere, increasing the CO^2 content of the atmosphere.

Teachers Notes.

Students may work in small groups; each group might review one statement and present their findings to the class.

THE CARBON DIOXIDE CYCLE AND COAL FORMATION



(from Pa. Geological Survey, Educational Series No. 7)

Activity: How Coal is Formed

Objective:

To have the student simulate and observe some conditions found in coal formation.

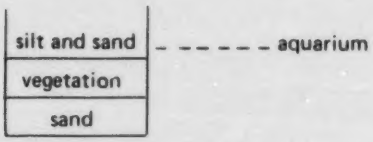
What to do:

Take an aquarium half filled with water, and sift into it fine- and medium-grained sand approximately 2 inches thick. Drop a few ferns, leaves, and small twigs into the aquarium and let stand for a few weeks, observing the changes in decomposition and color. Then sift fine silt and sand to a depth of 2 inches and observe the *coal layer* (vegetation between the sediment layers). Take out the water after the sediments settle and let the sediments dry for a few weeks. Plant imprints simulating the fossil plants found in coal can be observed when the sediments are examined.

Teachers Notes:

Materials needed: an aquarium, fine- to medium-grained sand, small ferns, leaves, plant parts, fine-screen wire or sifter, fine silt and sand.

Place in a ventilated area (stagnant water and decaying vegetation produce odors and gases).



Activity: Coal in Pennsylvania

Objective:

To study the geographic location of Pennsylvania's coal fields.

What to do:

Answer the following questions and become familiar with the location of coal types found in our state.

1. Where do we find the anthracite fields? Is there more than one type of anthracite present?

2. Where do we find the bituminous coal fields? Are there several types of bituminous coals present? What are they? What is their relationship to each other geographically and to the anthracite fields?

3. Where do we find peat deposits?

4. In which rock classification (igneous, metamorphic, or sedimentary) would you place anthracite?

5. Why do we find anthracite in eastern Pennsylvania and bituminous coal in the western part of the state?

6. In what physiographic provinces of Pennsylvania are the anthracite and bituminous coals located? (Refer to the Pysiographic Provinces of Pennsylvania map.)

7. Does folding have an effect on the coal rank?

8. Compare the location of the peat deposits with the glacial deposits of Pennsylvania. Can you see any correlation? Why?

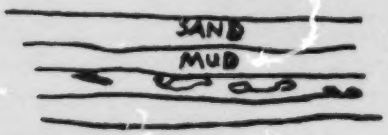
Teachers Notes:

References:

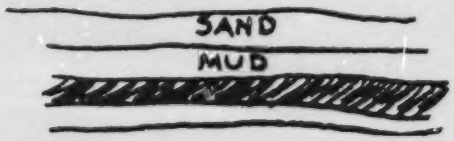
Pennsylvania Geological Survey Publications

THE GENESIS OF COAL

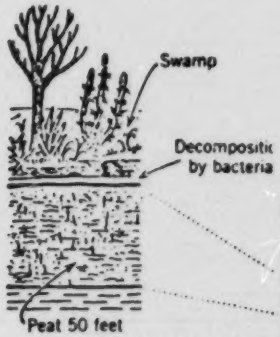
Plant material millions of years ago in swamps



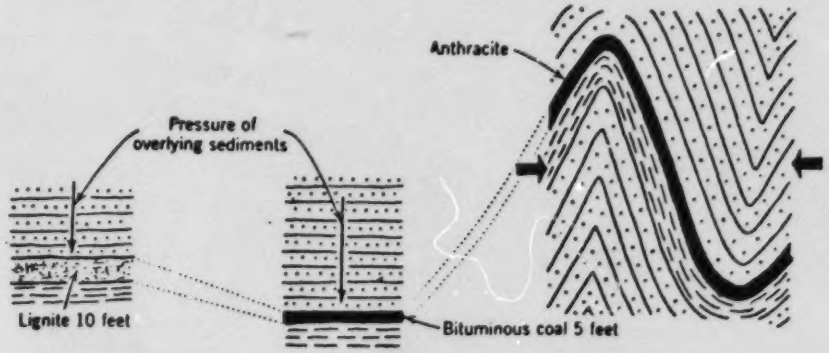
Plant material compressed and buried under many layers of sand and mud



Bacteria acts on remains to break down cell structure and reduce to fine fragments and jelly mass



As millions of years passed, these layers turned into the various forms of coal made up of primarily of carbon, hydrogen, with small amounts of oxygen, sulfur, nitrogen



Kinds of coal depends on where it is found and the amount of heat and pressure over time associated with its formation.

1. Distribution of Pennsylvania Coals - Map 11

2. Physiographic Provinces of Pennsylvania - Map 13

3. Pennsylvania and the Ice Age - Education Series 6

4. Peat Bog Investigations in Northeastern Pennsylvania - Information Circular 65

Answers:

1. Northeastern PA; yes, anthracite and semi-anthracite.

2. Southwestern PA; yes, high, medium, and low volatile bituminous; low volatile bituminous in the eastern part of the Appalachian Plateaus Province; the anthracite fields are east and north of the bituminous coals.

3. Northeastern and northwestern PA.

4. Metamorphic.

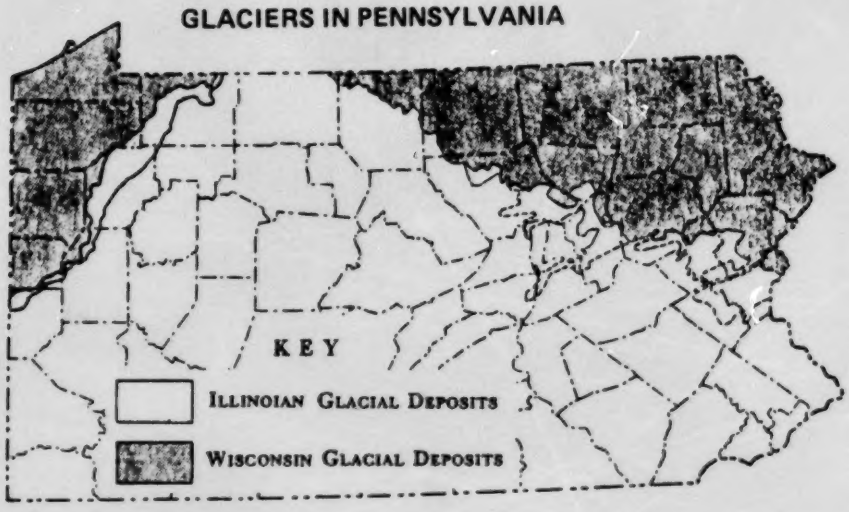
5. The metamorphism was strongest in the southeast and becomes less as it grades into the plateaus. The folding thrust came from the east-southeast; most of the pressure was in the east; observe the ridge and valley topography.

6. Valley and Ridge Province, Appalachian Plateaus Province.

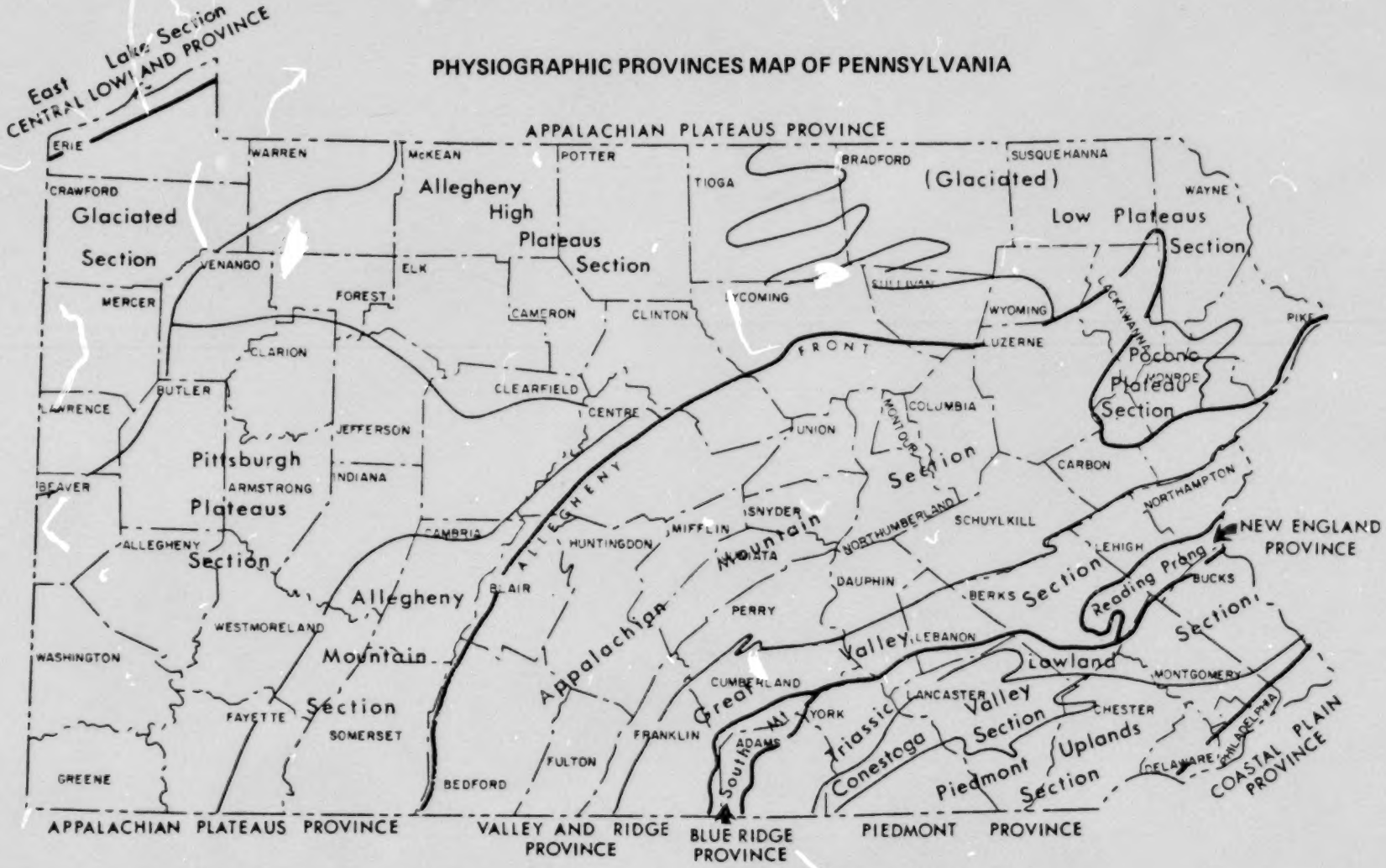
7. Yes; pressure.

8. Yes; peat found in the glaciated areas of PA; meltwater from the glaciers helped in peat bog formation.

GLACIERS IN PENNSYLVANIA



PHYSIOGRAPHIC PROVINCES MAP OF PENNSYLVANIA



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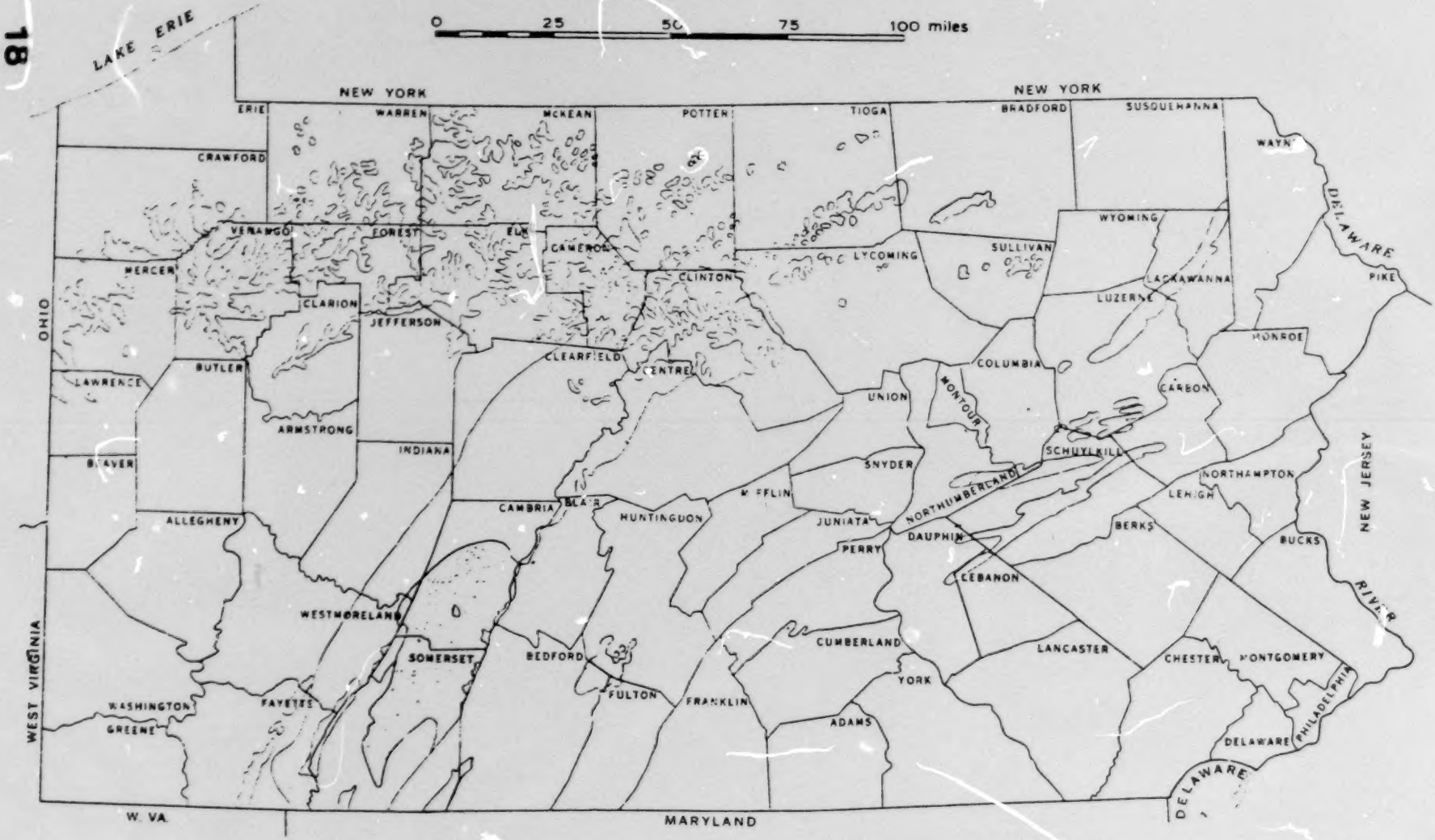
MAP OF PENNSYLVANIA COAL FIELDS



BITUMINOUS FIELDS

- High Volatile Bituminous Coal
- Medium Volatile Bituminous Coal
- Low Volatile Bituminous Coal

ANTHRACITE FIELDS

- Anthracite
- Semi Anthracite

Activity: Coal Exploration and Recovery

Objective:

To learn various methods of exploring for coal and how coal is mined.

What to do:

Coal exploration methods include digging a relatively shallow trench, drilling deep into the surface, and exploring the area for surface exposure of the coal.

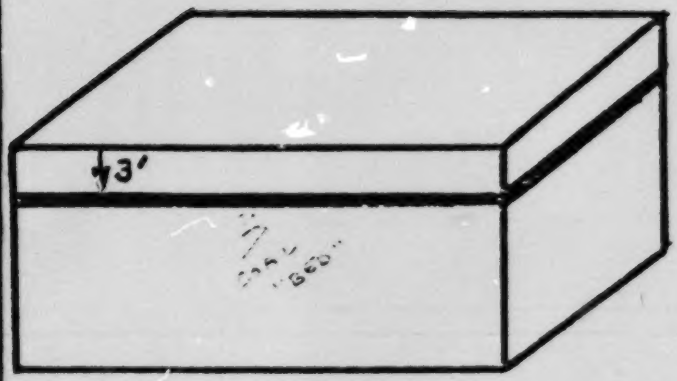
Using the block diagrams A, B, C, and D on the next page, answer the following questions:

1. How might we explore for the coal shown in each diagram?
2. In block C if we would drill at X, would we find coal?
3. In block C would we find coal outcrops on the other side of the valley?
4. What would be the mining method used in each case represented by the coal diagrams?

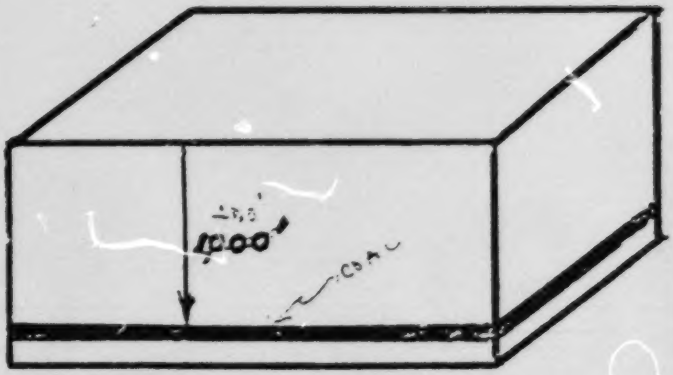
Read each set of statements below. If there were nothing else to consider, would you think that surface or deep mining (or both) is the best way to obtain the coal? Write your choices on the blanks at the left, using S (for surface) or D (for deep).

	SURFACE MINING	DEEP MINING
_____ 1.	Each miner can produce 30 tons of coal a day.	Each miner can produce 10 tons of coal a day.
_____ 2.	90 percent of the coal in a surface mine can be removed.	50-60 percent of the coal in a deep mine can be removed.
_____ 3.	In 1974, surface-mined coal cost $11.11 a ton.	In 1974, deep-mined coal cost $19.86 a ton.
_____ 4.	Forest and fields, along with their topsoil, are turned over before the coal is removed–at a rate of 1000 acres a week. State and federal laws require land reclamation, but the cost is added to the price of coal.	Much less damage to land and environment, is done in deep mining than in surface mining.
_____ 5.	Some coal, very close to the earth's surface, can be recovered only by surface mining.	Some coal, very deeply buried, can be recovered only by deep mining.

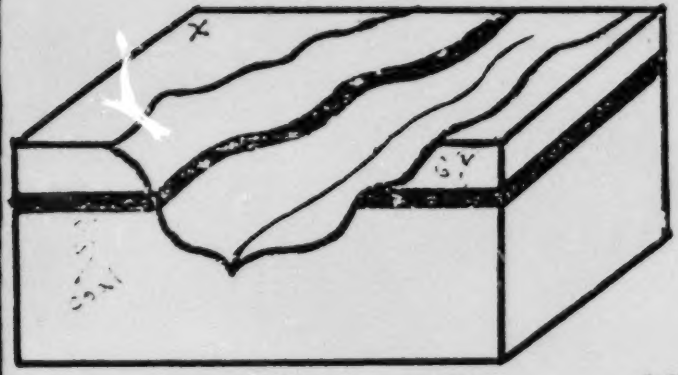
BLOCK DIAGRAMS SHOWING COAL BEDS



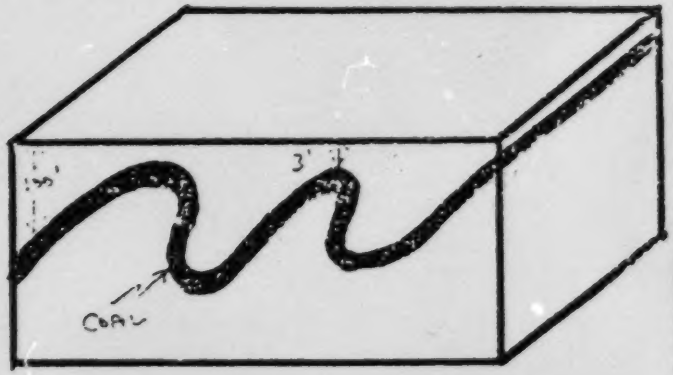
A



B



C



D

6. It would be easy to decide how to mine coal if there were only one set of facts to consider. As you have seen, however, there are many. What would you say is the main advantage of surface mining?

7. What would you say is the main advantage of deep mining?

Teachers Notes:

Coal is mined by either surface or deep mining. Surface mining uses huge bulldozers and power shovels to remove coal from a shallow seam near the earth' surface.

Deep mining involves tunneling or driving s shaft into the earth to the seam of coal, sometimes many hundreds of feet below the surface. Workers and equipment remove the coal through the tunnel or shaft.

Answers:

First activity

1. (A) trench (B) drill (C) walk the area for surface exposure (D) trench and drill

2. Yes

3. Yes

4. (A) surface (B) deep (C) surface (D) surface and deep

Second Activity

1. S 2. S 3. S 4. D 5. D 6. Economic
7. Environmental

Activity: Producing Coke and Useful Energy By-Products

Objective:

To observe coke production and the volatiles distilled in the process.

What to do:

Place a small amount of crushed coal (bituminous) in a standard pyrex test tube. The test tube should be about 25 percent full. Coal size should be medium to fine Carefully heat the coal.

1. Collect the volatiles and observe if the gases burn with a glowing splint.

2. Observe changes in moistened litmus paper when exposed to the gases.
Red litmus test for base (ammonia) turns blue.
Blue litmus test for acid (sulfuric acid) turns red.

3. Observe the residue material (COKE) after no more volatiles are produced.

Teachers Notes:

This experiment should be used as a demonstration only. Work should be conducted under a protected shield and ventilated hood–volatiles are dangerous. Collect the gases in a water collection trough. Consult a chemistry test for setup. Use caution when demonstrating; teacher should do activity before presentation to class.

Materials needed: bituminous coal, test tube, Bunsen burner, water collection trough, wide-mouth bottles, rubber tubing, one-hole stopper, short glass tube to fit stopper, test tube holder, wood splints, litmus paper.

COKE PRODUCTION AND DISTILLATION

Activity: Coal - Word Puzzle

Objective:

Within a specific time frame, determine the student or students who can identify the most words associated with coal, coal mining, coal processing, and use.

What to do:

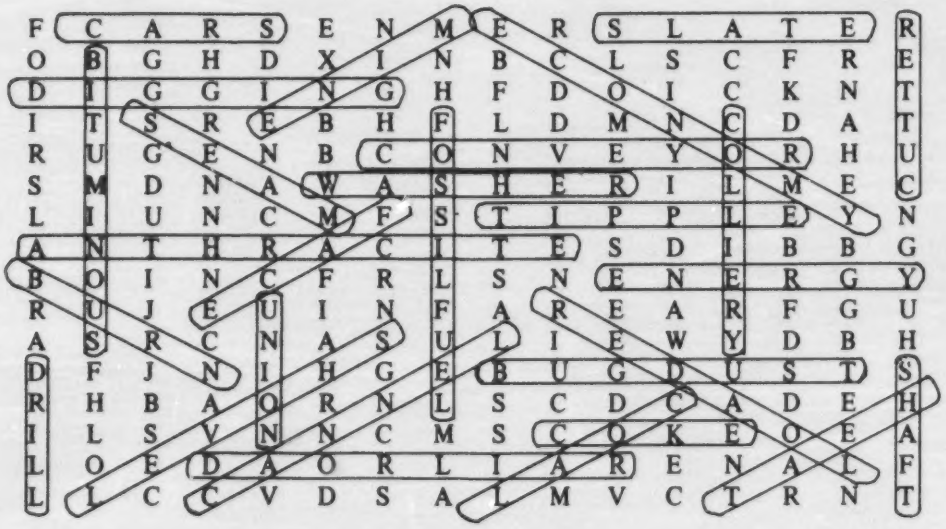
F	C	A	R	S	E	N	M	E	R	S	L	A	T	E	R
O	B	G	H	D	X	I	N	B	C	L	S	C	F	R	E
D	I	G	G	I	N	G	H	F	D	O	I	C	K	N	T
I	T	S	R	E	B	H	F	L	D	M	N	C	D	A	T
R	U	G	E	N	B	C	O	N	V	E	Y	O	R	H	U
S	M	D	N	A	W	A	S	H	E	R	I	L	M	E	C
L	I	U	N	C	M	F	S	T	I	P	P	L	E	Y	N
A	N	T	H	R	A	C	I	T	E	S	D	I	B	B	G
B	O	I	N	C	F	R	L	S	N	E	N	E	R	G	Y
R	U	J	E	U	I	N	F	A	R	E	A	R	F	G	U
A	S	R	C	N	A	S	U	L	I	E	W	Y	D	B	H
D	F	J	N	I	H	G	E	B	U	G	D	U	S	T	S
R	H	B	A	O	R	N	L	S	C	D	C	A	D	E	H
I	L	S	V	N	N	C	M	S	C	O	K	E	O	E	A
L	O	E	D	A	O	R	L	I	A	R	E	N	A	L	F
L	L	C	C	V	D	S	A	L	M	V	C	T	R	N	T

Teachers Notes:

The following words may be found in the puzzle:

1.	Anthracite	8.	Coke	15.	Energy	22.	Seam
2.	Bituminous	9.	Colliery	16.	Face	23.	Shaft
3.	Bug Dust	10.	Conveyor	17.	Fossil Fuel	24.	Shovel
4.	Burn	11.	Cutter	18.	Heat	25.	Slate
5.	Cannel	12.	Digging	19.	Loader	26.	Tipple
6.	Cars	13.	Drill	20.	Mine	27.	Union
7.	Coal	14.	Economy	21.	Railroad	28.	Washer

SOLUTION:


F C A R S E N M E R S L A T E R
O B G H D X I N B C L S C F R E
D I G G I N G H F D O I C K N T
I T S R E B H F L D M N C D A T
R U G E N B C O N V E Y O R H U
S M D N A W A S H E R I L M E C
L I U N C M F S T I P P L E Y N
A N T H R A C I T E S D I B B G
B O I N C F R L S N E N E R G Y
R U J E U I N F A R E A R F G U
A S R C N A S U L I E W Y D B H
D F J N I H G E B U G D U S T S
R H B A O R N L S C D C A D E H
I L S V N N C M S C O K E O E A
L O E D A O R L I A R E N A L F
L L C C V D S A L M V C T R N T

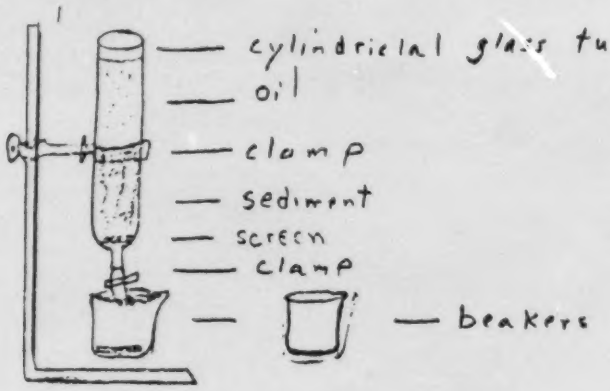
Activity: Oil - Occurrence and Movement

Objective:

To be able to describe the occurrence of oil in rock and how it moves through the rock.

What to do:

The simplest method of measuring the porosity of granular material is by saturating a dry sample with a fluid to determine the volume of its pores. In this experiment you are to determine the porosity of three grades of sediments (fine sand, medium sand, and course limestone chips). Determine the porosity of each sediment material by measuring the amount of water or oil (#10 weight) required to saturate 300 ml of it. To get an idea of the permeability of each sediment type, put 300 ml of water or oil above the already saturated sediment and record the time in seconds required to bleed 200 ml of oil or water through each of the sediments. See diagram for laboratory set-up.



type of sediment		fine	medium	coarse
porosity				
time	1			
	2			
	3			
mean average				

Teachers Notes:

Some sedimentary rocks allow fluids, such as oil, natural gas, and water to move through the interconnected void space or pore space between the sediment particles. The tiny droplets of oil that formed in the pore spaces of the buried sediments seep and migrate slowly through the pores in the rock to places where they are trapped. (See Activity #10) The percentage of void space in the total volume of a material is termed porosity. Porosity is dependent upon packing, sorting, size, shape, distribution, and orientation of the mineral particles. The permeability, or interconnection of void spaces in the sedimentary rock, is a function of size, shape, arrangement, and continuity of the voids.

Graphic examples of rock porosity:

Certain Sandstone (magnified)

Large amounts of oil are stored and can move freely around grains of sand.

Certain other Sandstone (magnified)

Moderate amounts of oil are stored and can move through a network of narrow cracks formed by intersecting fractures and openings between rock layers.

Shale (magnified)

Moderate to small amounts of oil are stored but can move difficulty through a network of fine cracks formed by intersecting fractures and openings between rock layers.

Limestone (magnified)

Small to large amounts of oil are stored and move easily through solution channels, fractures, and openings between rock layers.

Crystalline rocks (magnified)

Small to moderate amounts of oil are stored and can move with difficulty through a network of fine cracks opened by fractures.

This being a wet laboratory activity paper towels are needed. The porosity for equal volumes of graded sediments will be the same. Using 150 ml of course limestone chips (0.5 - 1.0 cm in size) and 150 ml of water above the sediment, the average time to bleed 20 ml of water was about 3 seconds. 12 seconds was the average time to bleed 20 ml of water from 150 ml of fine sand sediments. The results will vary with the size of the glass tube used, but the time for the coarse limestone chips will be less than the fine sand sediments time.

Equipment needed: two beakers (500 ml), ringstand, cylindrical glass tube with a screen base, clamps, fine, medium, and course sediments (sand and gravel).

Activity: Oil and Gas in Pennsylvania

Objective:

To study the geographic location of Pennsylvania's oil and gas fields.

What to do:

Answer the following questions:

1. Where do we find oil and natural gas fields?
2. How do the oil and gas fields compare in location to the coal fields?
3. Does the map show that oil and gas are always found together?
4. In what physiographic provinces do we find the oil and gas fields?
5. Is structure important in oil and gas deposits?
6. How do we explore for oil and natural gas?

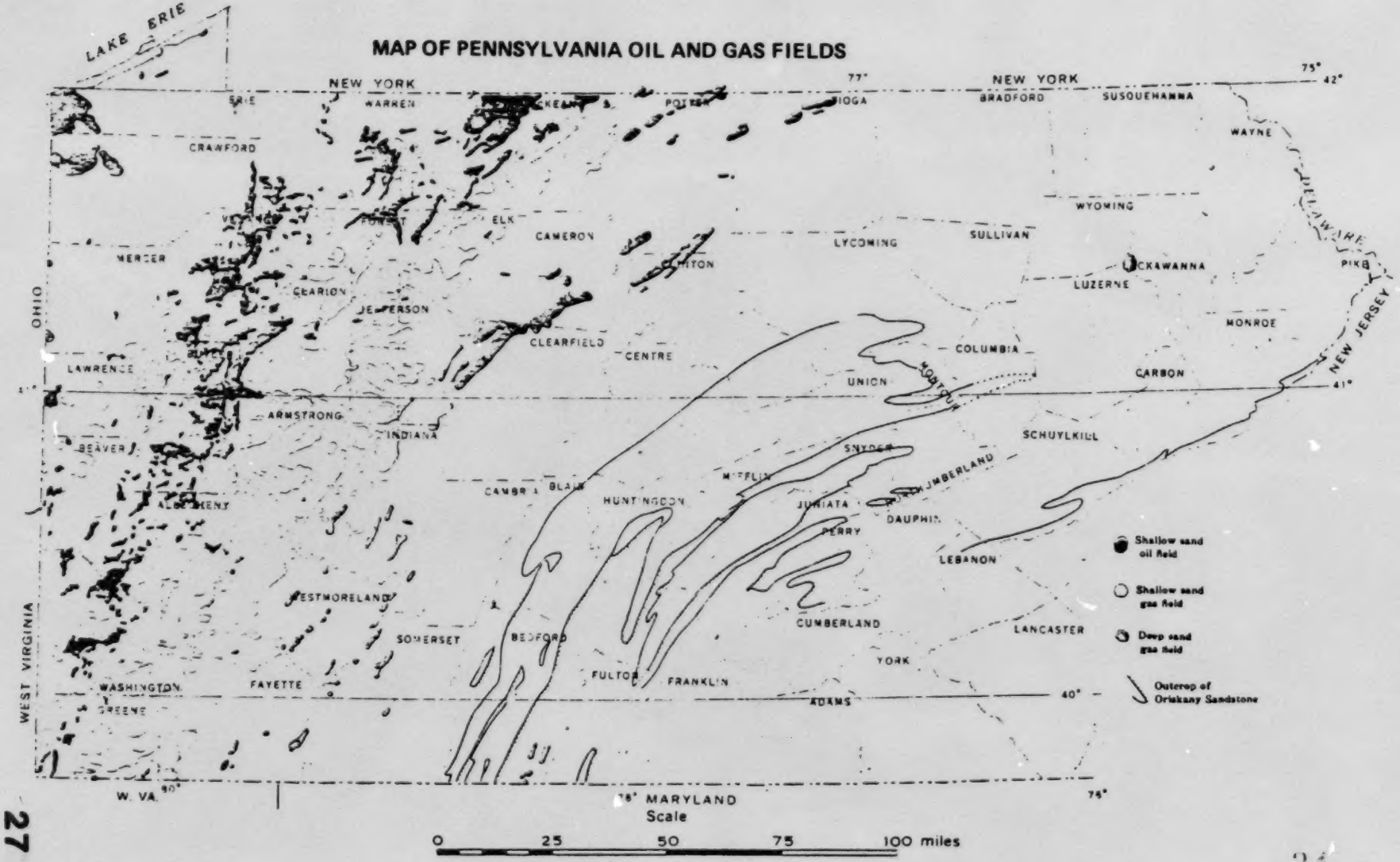
Teachers Notes:

References:

1. Distribution of Pennsylvania Coals - Map #11, PA Geological Survey
2. Oil and Gas Fields Map of Pennsylvania - Map #20, PA Geological Survey
3. Physiographic Provices of Pennsylvania - Map #13, PA Geological Survey
4. The Pennsylvania Energy Primer: p. 10 - Typical Oil Traps and Typical Drilling Results

Answers:

1. Western third of PA
2. About the same as the bituminous fields and to the northwest
3. No
4. Appalachian Plateaus Province
5. Yes
6. Seismic expioration and drilling


MAP OF PENNSYLVANIA OIL AND GAS FIELDS
LAKE ERIE
NEW YORK
NEW YORK
77°
75°
42°
41°
40°
ERIE
WARREN
POTTER
TIOGA
BRADFORD
SUSQUEHANNA
WAYNE
CRAWFORD
MERCER
VENANGO
FOREST
ELK
CAMERON
LYCOMING
SULLIVAN
WYOMING
LACKAWANNA
LUZERNE
PIKE
DELAWARE
NEW JERSEY
MONROE
CLARION
JEFFERSON
CLEARFIELD
CENTRE
COLUMBIA
MONTOUR
CARBON
OHIO
LAWRENCE
BUTLER
ARMSTRONG
INDIANA
UNION
SCHUYLKILL
BEAVER
SNYDER
MIFFLIN
CAMBRIA
BLAIR
HUNTINGDON
JUNIATA
DAUPHIN
ALLEGHENY
PERRY
LEBANON
WESTMORELAND
CUMBERLAND
LANCASTER
SOMERSET
BEDFORD
YORK
WASHINGTON
FAYETTE
FULTON
FRANKLIN
ADAMS
GREENE
W. VA.
MARYLAND
Scale
0
25
50
75
100 miles
Shallow sand oil field
Shallow sand gas field
Deep sand gas field
Outcrop of Oriskany Sandstone

27

34

Activity: Oil and Gas Exploration

Objective:

To enable the student to describe common types of oil traps and exploration methods for oil and gas.

What to do:

1. Given the following diagrams of rock structure and rock strata, mark the most likely places where oil or natural gas would be located.

2. How do we explore for natural gas and oil?

3. Why is Pennsylvania number one in gas storage?

4. Describe seismic exploration.

Teachers Notes:

Some of the most common types of oil traps are produced by folding and faulting of the rocks. Anticlines and domes represent common types of structural traps in which oil will migrate up and dip along the limbs of the fold and form a pool in the crest of the fold beneath the impervious caprock. An oil trap can be produced through faulting by bringing a reservoir rock in juxtaposition with an impermeable bed, thus producing an oil pool adjacent to the fault plane. Natural gas traps occur in much the same way as oil traps.

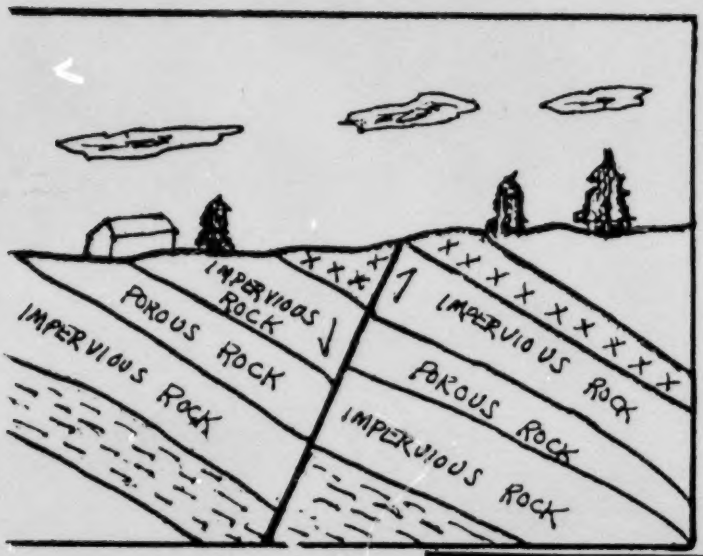
Answers:

1. The Pennsylvania Energy Primer: p. 10 Typical Oil Traps

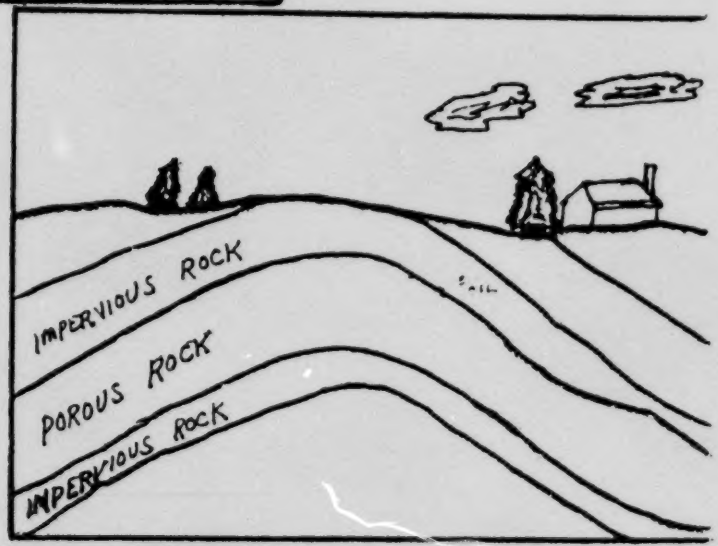
2. Drilling, seismic exploration, geologic structure

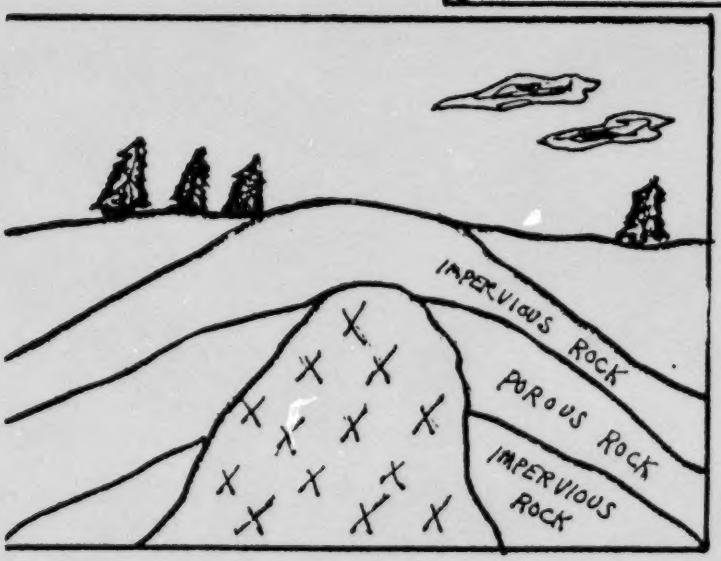
3. Many of the gas wells are depleted (empty) and can be used for storage

4. The use of artifically created seismic waves to determine rock strata and structure in search of economically important materials, such as oil and gas.



TYPICAL OIL TRAPS





REFERENCE:
Pa. Geological Survey,
Geology of Pennsylvania's
Oil and Gas,

Educational Series No. 8.

Activity: Fossil Fuels - Complete the Sentence

Objective:

To determine if student has a general, overall understanding of the source and location of oil and gas in Pennsylvania.

What to do:

Complete the statements with terms relating to the origin and geographic location of oil and gas.

1. Three chemical elements found in oil and gas are _____, _____, and _____.
2. _____ is the primary chemical element in oil.
3. Liquid fuels are made from _____.
4. _____ is an automobile fuel that is made from oil.
5. _____ is found in three different physiographic provinces.
6. _____ is found in only one physiographic province in Pennsylvania.
7. Oil and gas had their origins _____ of years ago.

Answers:

1. Hydrogen, carbon, and oxygen
2. Carbon
3. Petroleum
4. Gasoline
5. Natural gas
6. Oil
7. Millions

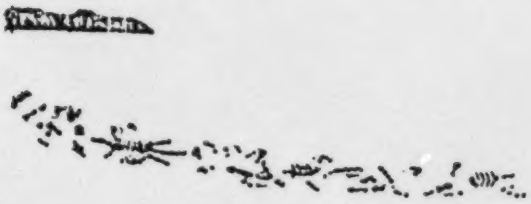
Activity: Earth's Thermal Energy

Objective:

To enable the student to describe the temperature and composition of the earth's interior as a source of energy.

THE ORIGIN OF OIL AND GAS

Geologists believe petroleum formations began millions of years ago, when tiny marine creatures abounded in and near the seas as they do today.

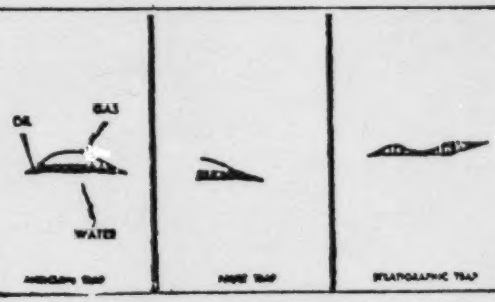


As millions of years passed, pressure compressed the deeply buried layers of mud, silt, and sand into layers of rock.

As marine life died, it settled to the sea bottom and became buried in layers of mud and sand

Earthquakes and other earth forces buckled the rock layers.

The organic matter held in mud and silt was changed to gas and oil, probably by gradual decay, heat, pressure, and possible bacterial and radioactive actions.



The petroleum migrated upward through porous rock until it became trapped under non-porous rock.

What to do:

Radioactivity is considered to be the primary source of the earth's interior heat. The following table indicates two types of igneous rock, the concentration of radioactive elements, and the heat produced. *Compare the heat production per gram with a gram of each of the fossil fuels.*

Radioactivity and Heat Generation in Common Rocks of the Earth's Crust

Rock	Concentration of Elements (Grams of element per gram of rock)			Heat Production (Calories* produced per gram of rock per second			
	Uranium	Thorium	Radioactive isotope of Potassium	Uranium	Thorium	Radioactive isotope of Potassium	Total
Granite	4×10^{-6}	13×10^{-6}	3.5×10^{-2}	9.2×10^{-14}	8.2×10^{-14}	3.0×10^{-14}	20×10^{-10}
Basalt	1×10^{-6}	3×10^{-6}	1.3×10^{-2}	2.3×10^{-14}	1.9×10^{-14}	1.1×10^{-14}	5.3×10^{-14}

*A calorie is a unit of heat. It is the amount of thermal energy necessary to raise the temperature of one gram of water 1 degree C.

Teachers Notes:

One of the major problems related to the earth's thermal history is the present temperature of the earth's deep interior. All we know about the temperature of the interior of the earth must come from mathematical models. To construct such a model we must make certain assumptions about the initial heat of the earth, the concentration of radioactive materials inside the earth, and the physical properties of materials in the earth's interior. These assumptions are not merely wild guesses, for they must be consistent with what is known. Much is yet to be learned, however, because different models or assumptions give different results.

The following statements support the belief that temperatures inside the earth are very high:

1. Geysers are found in southwestern United States, Iceland and New Zealand.
2. The deepest mines are too hot to be worked without air conditioning.
3. Steam from underground sources is used to generate electricity in Italy, Iceland, and California.
4. In Iceland, many homes are heated with hot water from the hot springs.
5. Lava, a molten rock, comes from volcanoes in a fluid condition.

Activity: Radioactivity

Objective:

To enable students to identify and define radioactivity and radioactive rocks and minerals.

What to do:

Through the use of a geiger counter, test various objects for radioactivity, particularly radioactive and non-radioactive rocks, watch dials, and pieces of old orange-colored fiesta ware. The latter is highly radioactive because uranium oxide was used in the orange glaze on the pottery.

Separate those substances which contain radioactive material from those that do not. What do those substances which cause the radioactive decay clicks (noise from the gieger counter) have in common? What causes the clicks in each one? What relationship does the number of clicks have to the level of radioactivity?

Teachers Notes:

One needs to be certain that the radiation which is recorded on the geiger counter is not coming from background radiation. Check the area before the object is brought within the vicinity of the geiger counter to hear the number and regularity of "clicks" related to the background radiation.

Activity: Uranium and Thorium

Objective:

To define how uranium and thorium occur; where they are found; how we find them.

What to do:

Matching Game

THE MATCHING GAME

1. Heavy mineral placer deposits bearing this element are known.
2. These two elements are abundant in the earth's crust.
3. This element forms a great variety of minerals.
4. High-grade uranium deposits mined today are of several types.
5. These deposits are the principal source of uranium in the U.S.
6. This type of deposit has been the main source of uranium in Canada.
7. Pennsylvania's uranium deposits are of this type.
8. Uranium deposits in sandstone are of two main types.
9. The most common yellow-colored uranium mineral.
10. Instruments that measure radiation.
11. Uranium is commonly mined by this technique.

A. South Africa
B. France
C. Uranium
D. Sandstone ore, uranium-bearing veins and ancient conglomerates
E. Sandstone ore
F. Ancient conglomerate
G. Low-grade uranium-bearing rock
H. Roll and tabular
I. Carnotite
J. Thorium
K. Mining
L. Uranium and thorium
M. Geiger counter and scintillometer
N. Open pit
O. Drill hole
P. Mine
Q. Mine
R. Gamma-rays

11

Teachers Notes:

Answers:

1.	J	6.	F	11.	N
2.	L	7.	G		
3.	C	8.	H		
4.	D	9.	I		
5.	E	10.	M		

Thorium is about three times more abundant in the earth's crust than uranium, hence its ultimate resources are greater than those of uranium. In some igneous rocks the two elements are closely associated, whereas in sedimentary rocks they usually occur alone. On weathering of igneous and metamorphic rocks, the resistant heavy minerals move gradually downslope and downstream. They become concentrated into economically important placer deposits at favorable places along stream courses and eventually in beach sands. Ancient thorium-bearing placer deposits, formed at an early stage of geologic history and preserved in sedimentary rocks, are also known.

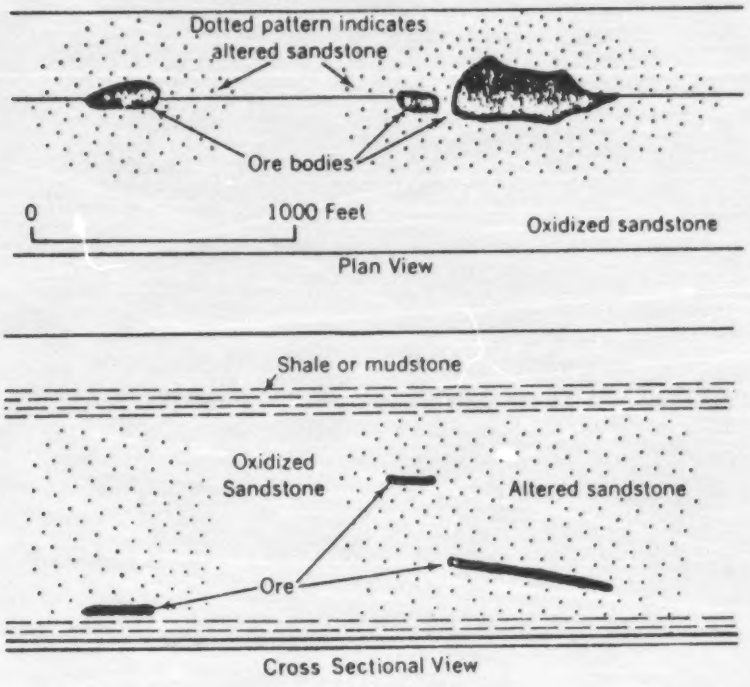
Uranium forms a great variety of minerals, many of which are in rich concentrations and constitute the high-grade deposits that are mined today. Those that have provided most of the uranium mines in the past 25 years are (1) sandstone impregnated with uranium minerals, (2) uranium-bearing veins localized in fractures in brittle rocks, and (3) ancient uranium placers in quartz-pebble conglomerate of Precambrian age. The sandstone ores have been the principal source of uranium in the United States. Vein deposits have been large sources of uranium in Canada, France, Australia, and Zaire (formerly Belgian Congo). The ancient conglomerate type has been a principal source in Canada and South Africa.

In addition to the three principal types of deposits now being mined, uranium resources also occur in bodies of low-grade uraniferous rock that are very large but too lean to be mined for uranium alone at present prices. Pennsylvania's uranium deposits are of this type.

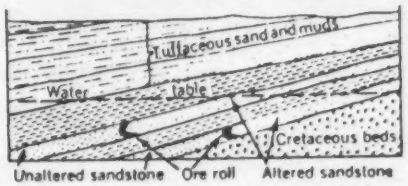
Uranium deposits in sandstone are of two main types: (1) "roll" bodies, in Wyoming, South Dakota, and south Texas, and (2) tabular bodies, in Colorado, Utah, Arizona, and New Mexico. Rolls are elongated bodies, crescent-shaped in cross section, that are scattered like beads on a string. The tabular bodies are discrete masses, like raisins in a slice of raisin bread.

Oxidation through weathering of uraninite commonly produces a number of bright yellow and green minerals; the most common yellow ore is carnotite. The ore minerals mainly occupy pore spaces in the sandstone, but in places they replace sand grains and carbonized plant fossils. The ore bodies range in size from a few feet across containing a few tons of ore to several thousand feet across (rarely more than a mile) containing more than 10,000,000 tons of ore.

CROSS-SECTIONAL AND PLAN VIEWS OF TABULAR URANIUM DEPOSITS



CROSS-SECTIONAL VIEW OF TYPICAL ROLL-TYPE URANIUM DEPOSITS



Instruments that measure the radiation emitted as radioactive elements decay are the most common tools used in prospecting for uranium and thorium. The main types are (1) Geiger counter, (2) scintillation counter, and (3) gramma ray spectrometer. These instruments are normally portable and they are often used to probe exploration drill holes. The Geiger counter detects both gamma rays and beta particles, or gamma rays only. A scintillation counter counts only gamma rays, is more sensitive, and can be made to respond faster than a Geiger counter. The gamma ray spectrometer, which has been developed in recent years, distinguishes between radioactive isotopes by measuring gamma radiations at particular energy levels. With this instrument, the mineral content of uranium, thorium, and potassium can be measured in a few minutes at an outcrop, or it may be used to survey large areas from an airplane.

Other direct methods used in prospecting are analyzing samples of water and soil for their uranium content. Panning for heavy materials is particularly useful in the search for placer concentrations of thorium minerals.

Methods of prospecting for uranium and thorium have changed in the last two or three decades. Since most domestic uranium and thorium occurrences of any importance that crop out on the surface have been found, future economic discoveries will probably be made by drill-hole exploration generally preceded by thorough geologic study.

Various mining methods are used to recover the uranium and thorium. Large open-pit mines are common in major uranium districts such as Wyoming and Texas. Underground mining from shafts several hundred to more than 1,000 feet deep characterizes the San Juan basin district in New Mexico. Very few thorium vein deposits have been explored at depth by drilling or underground excavations. A common method of recovering thorium-bearing monazite in placer deposits is by dredging, a process in which large amounts of gravel can be treated at low cost for recovery of the heavy minerals.

Environmental problems in exploiting high-grade uranium deposits are those common to all milling and open-pit and underground mining operations; an additional problem is radiation exposure, particularly the presence of radon gas in mines and tailings.

ILLUSTRATIONS OF RADIATION DETECTING INSTRUMENTS

References

1. Energy Resources of the United States. U.S. Geological Survey Circular 650.

2. Nuclear Energy Resources–A Geologic Perspective, U.S. Geological Survey Popular Pamphlet.

Activity: Nature's Lightest Metal

Objective:

Since this metal may play a major role in solving our energy problems, an understanding of its occurrence and new use is exciting.

What to do:

A complete-the-sentence exercise may be used to measure the student's grasp of the material presented.

1. _____ is the lightest of all metals.

2. Lithium can be split to form _____.

3. _____ and _____ react to produce very large amounts of energy.

4. _____ can be recovered from water.

5. Lithium occurs naturally in several geologic settings: _____, _____ and _____.

6. In Pennsylvania, _____ is an important source of lithium.

Teachers Notes:

Answers:

1.	Lithium	4.	Deuterium
2.	Tritium	5.	pegmatities, lithium-rich waters, clays and shales
3.	Deuterium, tritium	6.	Brine

Lithium will probably be required in the electrical power generating plant of the future–the thermonuclear (fusion) power plant. In a controlled thermonuclear reaction, the two heavy isotopes of hydrogen, deuterium and tritium, react to produce very large amounts of energy. Deuterium can be recovered from natural waters, but tritium is obtained only by the neutron bombardment of lithium. Thus, tritium is

obtained as a byproduct of the deuterium-tritium reaction if lithium is present in the thermal blanket surrounding the fusion reaction chamber. Although only a small amount of lithium is actually spent to form tritium, the thermal blanket may contain a large reserve of lithium so that it can serve the added functions of absorbing neutrons and providing a heat transfer agent to power a conventional steam generating plant.

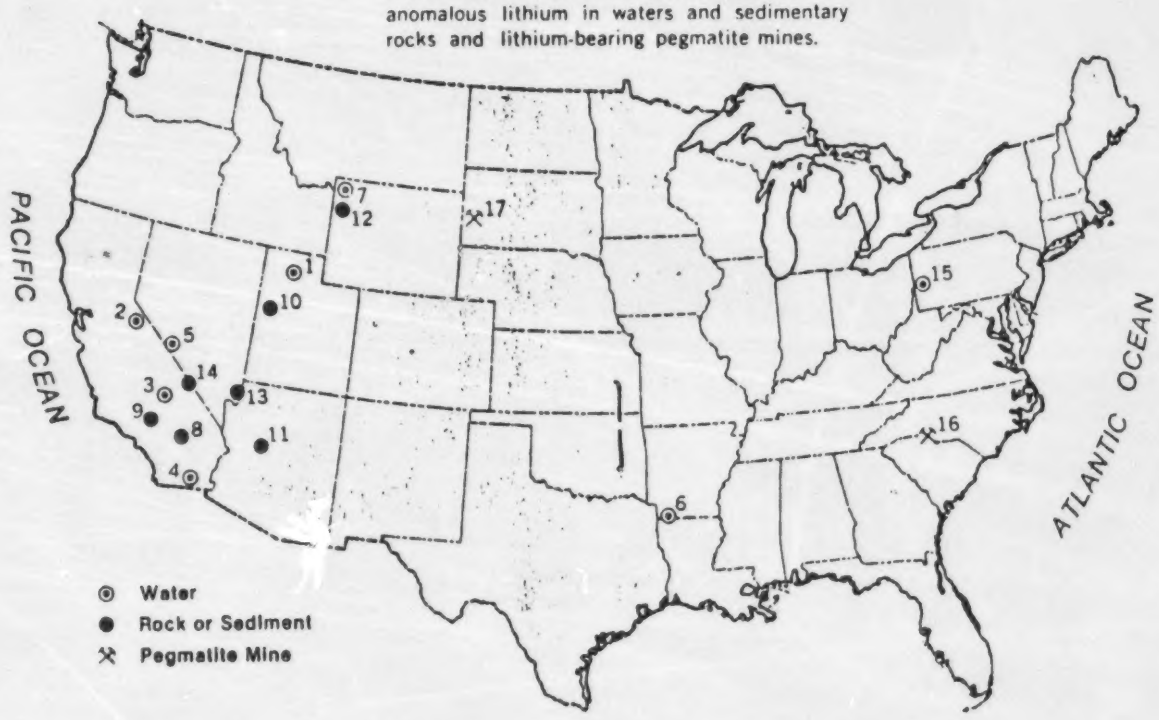
Although many lithium-bearing minerals are known, most are found only in certain rare pegmatities (course-grained igneous rocks) and in alteration zones of igneous rocks.

Lithium also occurs in clay minerals and shales as well as in desert lakes and underground brines of dry desert lakes. Common rocks, minerals, and sediments contain only trace quantities of lithium, generally less than 100 parts per million (ppm). Fresh waters generally contain less than 1 ppm; seawater contains an average of less than 0.2 ppm lithium.

Three lithium silicate minerals (spodumene, lepidolite, and petalite), as well as the lithium phosphate mineral, amblygonite, have been commercial sources.

Lithium is concentrated in certain waters and brines associated with petroleum. For example, a number of wells that produce oil from Pennsylvania yield brine with unusually high concentrations of lithium. Concentrations as high as 500 ppm lithium have been reported. In some areas, lithium is probably dissolved out of salt beds and other rocks associated with the salt deposits. The chemical composition of these waters is too complex, however, to be explained by a simple solution mechanism, and several alternatives have been suggested that invlove filtration through beds of shale and chemical reaction with various minerals in the rocks.

Map of the United States showing areas of anomalous lithium in waters and sedimentary rocks and lithium-bearing pegmatite mines.



References

1. **Lithium, Nature's Lightest Metal**, U.S. Geological Survey, Popular Pamphlet.

2. **The Occurrence of Brine in Western, Pennsylvania** Pa. Geological Survey, Bull. M-47.

Activity: Hot Springs and Geysers

Objective:

To introduce a relatively small source of energy, but possibly an important one in the total picture of energy resources.

What to do:

For a simple working model of a geyser, use a coffee percolator.

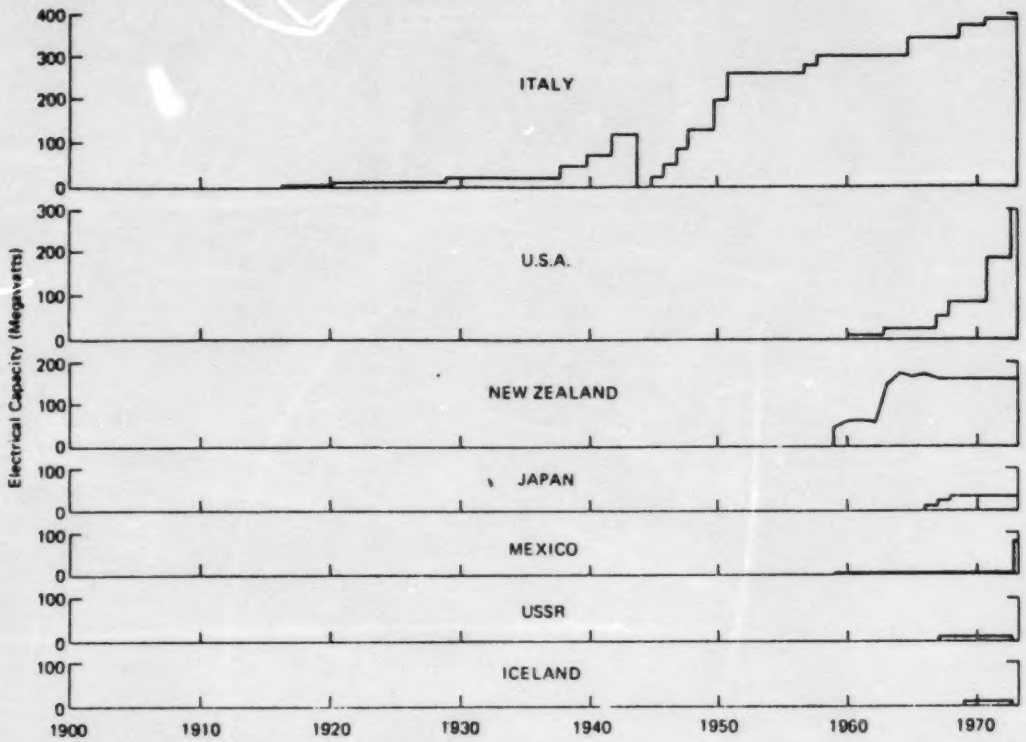
Teachers Notes:

Electricity can be made from heat coming from the earth's interior in the form of hot springs and geysers. By 1979, according to Energy Conservation Research, total installed geothermal capacity in the U.S. will be about 650 megawatts. By 1985 goethermal generation capacity may reach 10,000 megawatts - about one percent of our nation's total electrical generation capacity. This will not be a significant energy source, but will be a useful addition to our total energy inventory. Countries making use of geothermal energy for producing electricy include Italy, New Zealand, United States, Japan, Mexico, the Soviet Union, and Iceland. In 1978 California was producing about 500 megawatts of electricity from the geothermal plant at the Geysers.

References

1. **Natural Steam For Power**, U.S. Geological Survey Popular Pamphlet.

2. **Geysers**, U.S. Geological Survey Popular Pamphlet.



Growth of geothermal generating capacity by countries from 1900 to 1972. (Source: D. A. Brobst and W. P. Pratt, eds., U.S. Geological Survey Professional Paper 820, 1973.)

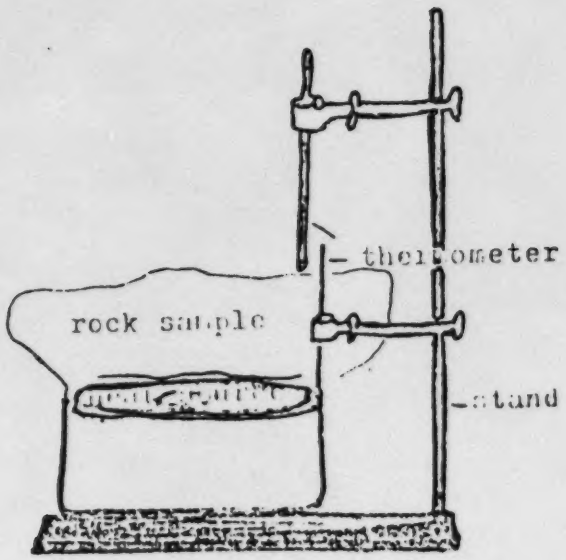
Activity: Hot Rocks

Objective:

To introduce a relatively new idea in developing our energy resources–power generation from hot, dry rocks.

What to do:

Construct a model to measure transmission of heat energy through rocks. To measure heat transmission through a rock sample, place a hand-specimen about 1 cm above a heat source (hot plate) that has been preheated for about 5 minutes, or a length of time to reach near its maximum temperature. Select a length of time 5 to 20 minutes for the rock sample to be heated, and measure the temperature on the heat source side and the top side of the rock with a thermometer calibrated for the types of temperatures in this exercise. See the following figure for the basic idea. Modifications could be considered.



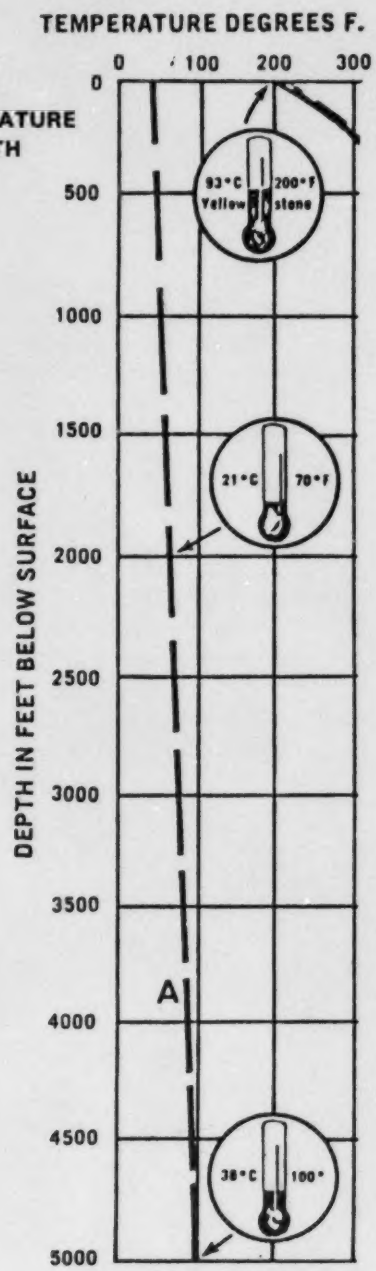
rock type	time sample heated	hot plate temperature		rock temperature
granite		this will be a constant		temp.
basalt		"		
sandstone		"		
limestone		"		
marble		"		
quartzite		"		

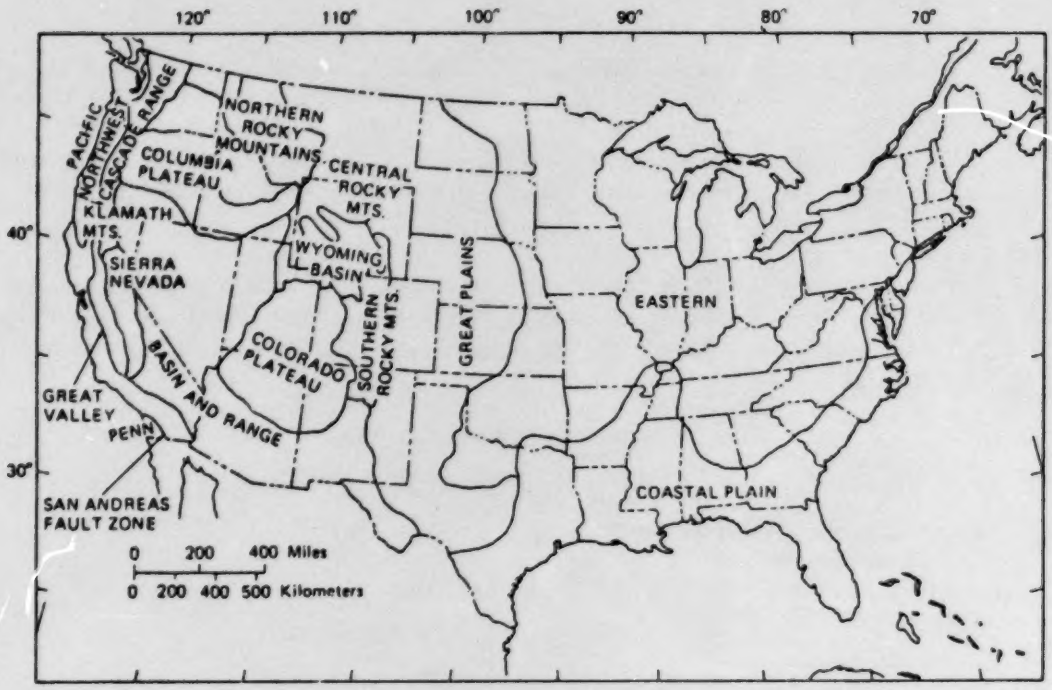
Teachers Notes:

Hot spots in the United States involve, in part, hot igneous systems with a large quantity of hot, dry rocks. Some of these geothermal reservoirs of hot, dry rocks may be accessible to drilling and fracturing. Cold water could then be injected into the rock at one location and hot water pumped out at another where the heat could be recovered. This induced circulation of water would mine the heat of the hot, dry rock system.

Note: Some rocks will fracture and break when heated. Use a protective shield and eye glasses. Do not place rock samples directly on the hot plate (about 1 to 2 cm above it.) Also place the thermometer at the same distance. Do not disregard laboratory safety practices.

GRAPH SHOWING TEMPERATURE INCREASE WITH DEPTH





Map showing the generalized extent of hot (shaded), normal (white), and cold (stippled) crustal regions of the United States. Also shown are the major physiographic provinces such as the Colorado Plateau. (Source: D. F. White and D. L. Williams, eds., U.S. Geological Survey Circular 726, 1975.)

References

1. **Geysers**, U.S. Geological Survey Popular Pamphlet.

2. **Assessment of Geothermal Resources of the U.S.**, U.S. Geological Survey Circular 726.

Activity: Oil From Shale and Sand

Objective:

To introduce a potentially vast energy resource - oil shale.

What to do:

Matching Game

1. Certain rocks could yield oil.
2. When treated in this manner solid organic matter in the shale is converted to oil.
3. This treatment of the oil would be required to produce a marketable high-quality synthetic crude.
4. Total possible reserves in the U.S. may be in excess of this figure.
5. This formation in Colorado, Utah, and Wyoming contains the best-known oil shales.
6. Total identified oil shale resources of the world.
7. Rocks that are impregnated with semi-solid and solid petroleum products.
8. Large accumulations of tar sands are known from this area.
9. This formation is the best-known source of oil rock in Canada.
10. A large open-pit mine is now operating and yielding about 50,000 barrels of synthetic crude oil per day.
11. This will be the most likely method of mining oil shales.
12. Development of oil shales may involve the environment.
13. Pennsylvania may have large resources of these petroliferous rocks.

A. Green River Formation
B. 2 trillion barrels
C. Unita Basin
D. Tar sands
E. Lenses, beds
F. Retort
G. 30,000 sq. miles
H. Alaska
I. 3 trillion barrels
J. Significant disruption
K. Alberta, Canada
L. Shale
M. Pennsylvania
N. Great Candian Oil Sands Ltd.
O. United States
P. Hydrogeneration
Q. Underground
R. Open pit
S. Athabasca tar sands
T. Black shales

Teachers Notes:

Answers:

1.	D or L	8.	K
2.	F	9.	S
3.	P	10.	N
4.	B	11.	R
5.	A	12.	J
6.	I	13.	T
7.	D		

References:

1. **Oil Shale**, U.S. Geological Survey Popular Publications.
2. **Environmental Geology** by Edward A. Keller, Charles E. Merrill Publishing Company.

Activity: Pumped Storage–Efficient Hydroelectric Energy

Objective:

To be able to describe pumped storage and why it may be desirable.

What to do:

As a project the students may construct a working pumped storage model.

Teachers Notes:

Running water can be used to power electric generators and produce electricity. Water runs at a nearly constant rate in a given stream, yielding a constant amount of power. The use of electricity is not constant–it is much greater during the daytime hours. One solution to the problem of meeting the demands during peak power (demand times) is pumped storage.

During times of low demand, excess electricity is used to pump water to a high reservoir. When the power demand increases, the water which was pumped to the high reservoir is used to generate the additional electricity required. Pumped storage, then, is simply the storing of water during periods of low energy consumption to meet the demands during periods of higher consumption.

Reference

Pennsylvania Energy Primer, pages 27-35.

Activity: The Ocean as an Energy Source

Objective:

To explore two ways in which the ocean can be harnessed to supply energy.

What to do:

This is an opportunity for the students to do some research on an individual basis or in small groups. Report to the class on the following topics:

1. The sea thermal power cycle
2. Temperature range of the ocean and its use to produce electrical power
3. Tidal energy
4. Feasibility of a tidal energy generating plant in the Bay of Fundy.

Teachers Notes:

Reference

Pennsylvania Energy Primer, p. 46.

Activity: The Sun's Energy Output

Objective:

To calculate the sun's energy and compare it with other energy sources.

What to do:

The radiant energy arriving on the earth amounts to about two calories per square centimeter every minute. Of the total amount of energy radiated from the sun, this is but a small fraction. The sun radiates energy in all directions. In this exercise you are to calculate the energy output of the sun, using a giant sphere around the sun with a radius equal to the sun-earth distance.

Teachers Notes:

Answers:

- At earth, the sun's radiation = 2 cal/min on each cm^2

- Earth-sun distance, $r = 1.5 \times 10^8$ km $= 1.5 \times 10^{13}$ cm

- Area of a sphere - $4 \ r^2$

- There are $4 \ (1.5 \times 10^{13} \text{ cm})^2 = 2.8 \times 10^{27} \text{ cm}^2$ at earth's distance from the sun

- Radiation from the sun in all direction $L = 5.6 \times 10^{27}$ cal/min (called the *luminosity*)

- Length of time sun has been shining = 3×10^9 years or more (geologic evidence)

- Number of minutes in a year - $60 \times 24 \times 369 - 5.25 \times 10^5$ minutes *Total energy output* of sun is *more* than $L \times 3 \times 10^9$ years $= 5.6 \times 10^{27}$ (cal/min) $\times 3 \times 10^9$ (yr) $\times 5.25 \times 10^5$ (min/yr) $= 8.9 \times 10^{42}$ calories, or more

- Mass of sun $= 2 \times 10^{33}$ g

- Total energy output per gram $= \frac{8.9 \times 10^{42} \text{cal}}{2 \times 10^{33} \text{ g}}$

$= 4.5 \times 10^9$ cal/ g, or more

For comparison:

- Total energy per gram of burning gasoline $= 3 \times 10^3$ cal/g

- Total energy per gram of matter falling into the sun $= 5 \times 10^7$ cal/g

- Total energy per gram of hydrogen converted to helium $= 1.5 \times 10^{11}$ cal/g

Activity: How Fast Does the Sun Lose Weight?

Objective:

To enable a student to answer this question in one class period, with reasonable precision, and to challenge him to consider assumptions made in the computation.

What to do:

Construction of Calorimeters:

1. Cut 4 pieces of 1/4" lucite (plexiglass) 33 cm (13") square

2. Cut 8 strips of 1/4" lucite 1 cm wide and 33 cm long; cut off 1/2" from each of four of these strips

3. Drill a 1/2" hole 1/2" from one end of each of two of the short strips

4. Glue together (using 3% lucite in trichloroethane) to make two square "boxes" 33 cm square and 1 cm deep.

5. Coat the insides of the boxes with contact cement, affix aluminum foil smoothly to the cement, and glue on the tops to make two enclosed boxes of 0.1 square meter area. Insert a thermometer in a cork bored to fit the thermometer and place in the half-inch hole in each box.

6. A temperature rise of 10 degrees thus represents 10 kcal of heat received from the sun.

Procedure:

1. Place, in each box, one liter of water 5 degrees cooler than the air temperature in the shade; insert a thermometer in each box.

2. Place one box at right angles to the sun's incident rays (preferably at noontime) and place the other box nearby in the shade.

3. Note the time for the production of a 10 degree differential in temperature to occur in the two boxes (this represents 10 kcal/m^2 in the time noted). Errors due to heat capacity of the box and heat transferred to or from the surroundings are laregely compensated for by the shaded "control" box.

Calculations:

1. Considering this heat to be strinking each m^2 at distance 9.3×10^7 miles from the sun, and assuming a typical time of 10 minutes for the 10 degree rise, and using the following conversion factors:

1 min. = 60 sec 1 $m^2 = 3.86 \times 10^{-7}$ mi^2
1 kcal = 4.19×10^{10} erg
9×1020 erg = 1 g (from Einstein equation)
1,000 g = 2.2 lb 2,000 lb. = 1 ton

$$\frac{(10 \text{ kcal})\,(1 \text{ min})\,(1 \text{ mi}^2)\,(4 \text{ pi} \times (9.3 \times 10^7)\,(\text{mi}^2)\,(4.19 \times 1010 \text{ erg})\,(1 \text{ g})\,(2.2 \text{ lb})\,(1 \text{ ton})}{(10 \text{ min})\,(60 \text{ sec})\,(0.1 \text{m}^2)\,(3.86 \times 10^{-7} \text{mi}^2)\,(1 \text{ kcal})\,(9 \times 10^{20} \text{ erg})\,(10^3 \text{g})\,(2 \times 10^3 \text{lb})}$$

equals 2.4×10^6 tons/sec

Activity: **Solar Energy**

Objective:

To explore the many facets of solar energy

What to do:

Discuss how each of the items listed involve solar energy in some way.

A. Melting metal with a hand lens

B. Solar heaters

C. Wind

D. Evaporation of water

E. Melting of snow and ice.

F. Germination and growing of plants

G. Burning of wood

H. Photosynthesis

I. Clouds

Activity: World Reserves of Energy Resources

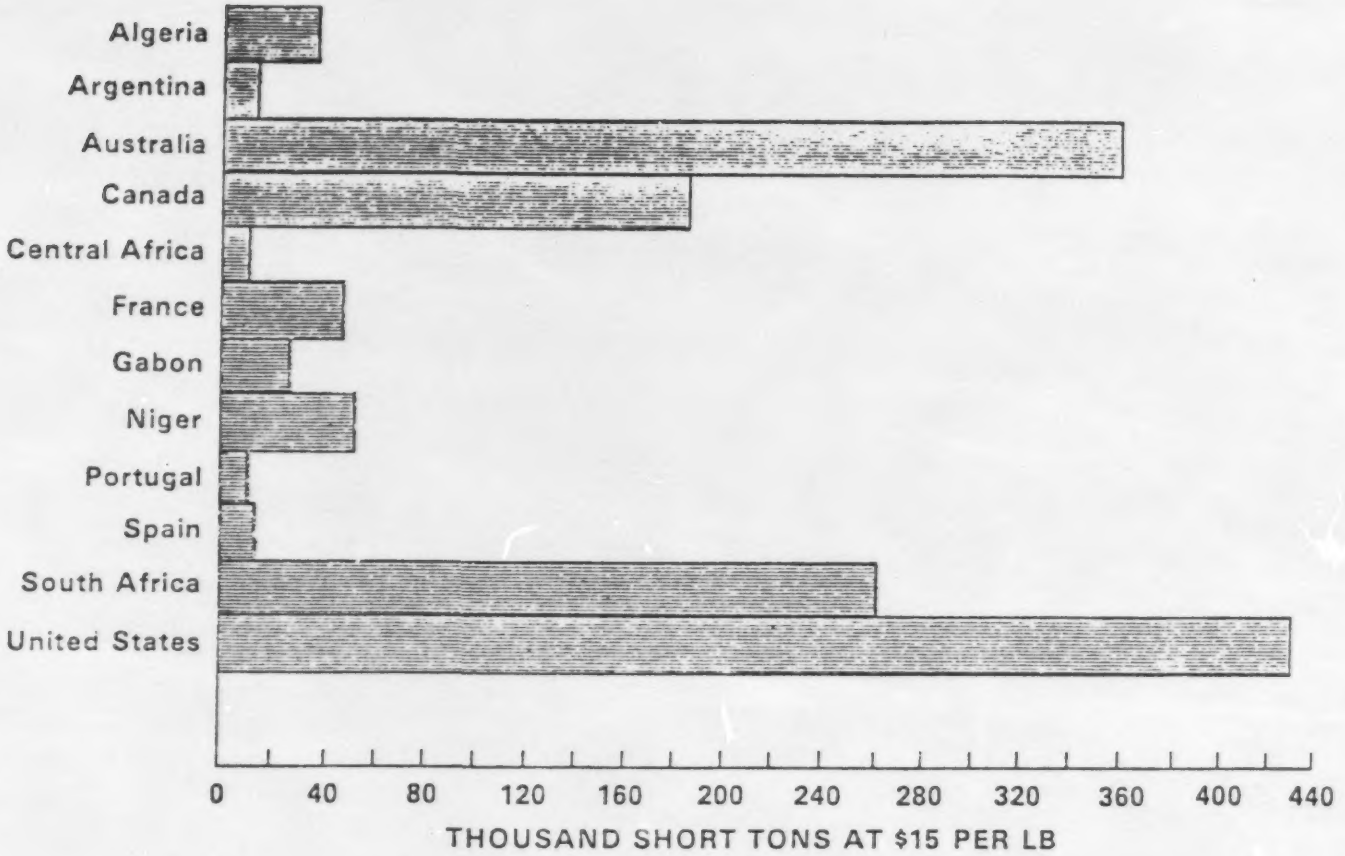
Objective:

To recognize the world distribution of energy resources.

What to do:

This chart will help the student easily recognize the areas ranked highest in each of the energy resources. Comparison of various sources can be of value.

	COAL	NATURAL GAS	OIL	URANIUM
United States	2	3	4	1
Other Western Hemisphere countries			5	4
Western Europe	3	5		5
Africa	5	4	3	3
Middle East		2	1	
Australia				2
Far East and Oceania	4			
Sino-Soviet Bloc	1	1	2	

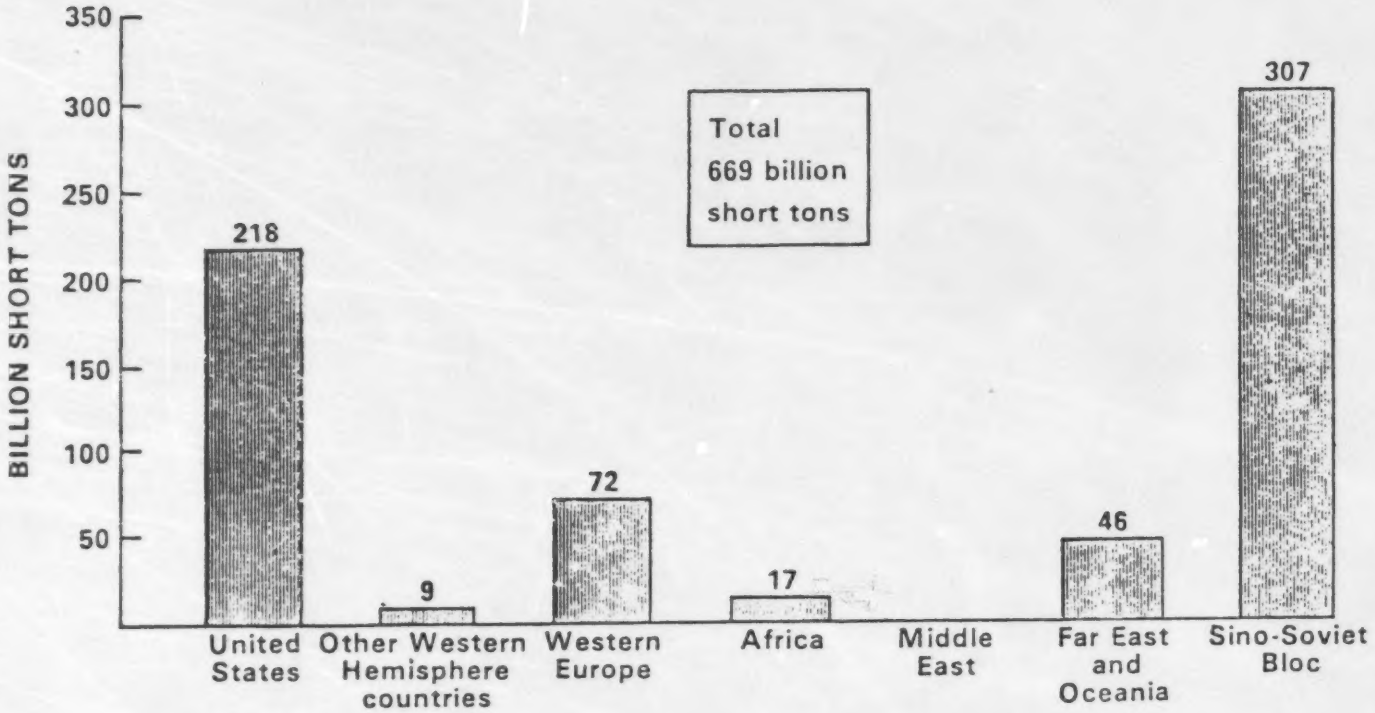


World Uranium Reserves, 1975

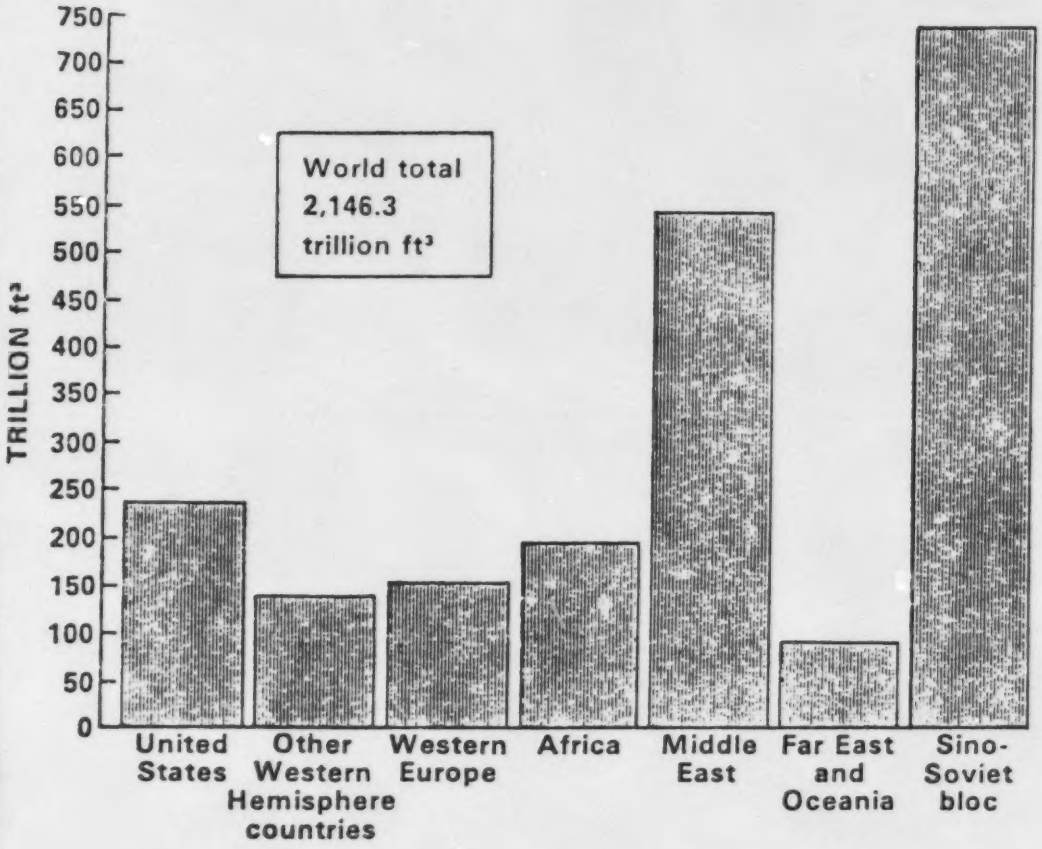
Teacher Notes:

The following graphs are from the U.S. Department of the Interior, Energy Perspectives 2, June 1976.

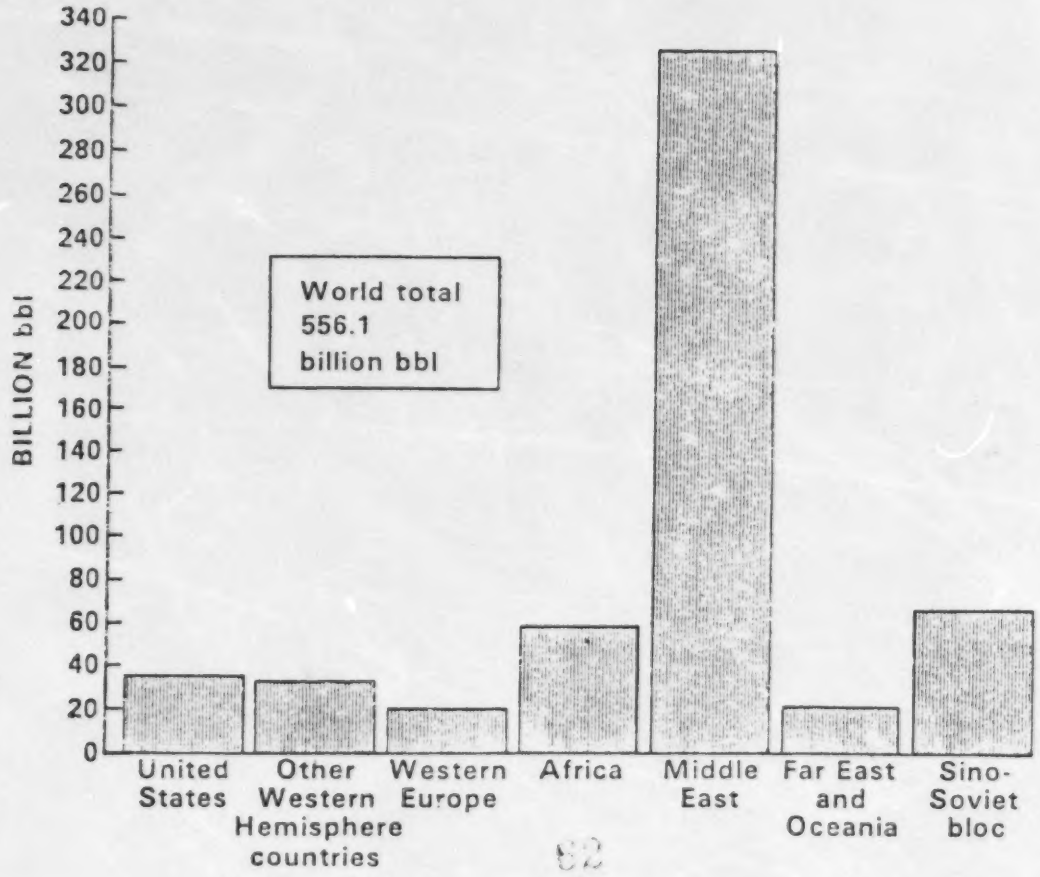
WORLD RECOVERABLE COAL RESERVES, 1974



World Estimated Natural Gas Reserves, January 1, 1975



World Estimated Crude Oil Reserves, January 1, 1975



Activity: Pennsylvania's Energy Resources

Objective:

To identify the location of major energy resources in Pennsylvania

What to do:

Rank the top ten counties in order of their energy reserves. Write the county name in the blank space on the chart. Show anthracite by underlining county name.

	COAL ANTHRACITE BITUMINOUS	NATURAL GAS	PETROLEUM	URANIUM
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Teacher Notes:

Answers

Top Ten Counties

	COAL ANTHRACITE BITUMINOUS	NATURAL GAS	PETROLEUM	URANIUM
1	Schuylkill Washington	Erie	McKean	Carbon
2	Luzerne Indiana	Beaver	Venango	Columbia
3	Northumberland Greene	Potter	Warren	Lycoming
4	Carbon Clearfield	Warren	Forest	Sullivan
5	Lackawanna Cambria	Westmoreland	Washington	Bradford
6	Dauphin Armstrong	Fayette	Butler	Berks
7	Berks-Snyder Somerset	Clinton	Crawford	Bucks
8	Columbia Clarion	Washington	Allegheny	Huntingdon
9	Sullivan Allegheny	Forest	Greene	Wyoming
10	Susquehanna Westmoreland	Clearfield	Elk	Lackawanna Wayne

References

Pennsylvania Geological Survey Publications

1. **The Mineral Industry of Pennsylvania in 1974**, Information Circular 82.
2. **Oil and Gas Developments in Pennsylvania in 1976**, Progress Report 190.
3. **Uranium in Pennsylvania**, Bulletin M 43.

Activity: Energy Resources–When Will They Be Gone?

Objective:

To find and compare estimates of the life of our energy resources on this planet.

What to do:

1. Make a chart to show the years to depletion of non-renewable resources on Planet Earth. One such esitmate is as follows:

Non-renewable Resource	Years to Depletion
Coal	300-400
Natural Gas	35-80
Petroleum	20-80
Uranium	60-70

2. Problem:

The recoverable fossil fuels for the world are estimated (in terms of 10^{15} kg of C) to be: Coal, 5.7; oil shale, 0.4; petroleum, 0.3; gas, 0.1; tar sand, 0.1; total 6.5 x 10^{15} kg of C. The U.S., with 6 percent of the world population, consumes about 3 x 10^{12} kg of carbonaceous fuel annually. If all the world's present population consumed these fuels at the U.S. rate, how long would the fossil fuel supply last?

Teachers Notes:

Answer:

3×10^{12} (kgC/yr) x 100/6 = 5×10^{13} (kgC/yr) required if all people used carbon fuels at the same rate as the U.S. does. 6.5×10^{15} (kg of C) ÷ 5×10^{13} (kgC/yr) = 100 yr of available carbon fuel if the present world population remains constant but suddenly all consume fuel at the U.S. rate. Most authorities assume carbon fuels will last from 300-500 years. This assumes much of the world remains undeveloped.

Students should check the library periodicals and energy publications for the numbers. Comparison of various sources can be of interest. See also the socio-economics of energy - **The Pennsylvania Energy Primer**, p. 36.